UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

SECOND CONTRIBUTION

TO THE

STUDIES ON THE CAMBRIAN FAUNAS

OF

NORTH AMERICA

BY

CHARLES DOOLITTLE WALCOTT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1886

THIS PAGE BLANK

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 30

WASHINGTON
GOVERNMENT PRINTING OFFICE
1886

THIS PAGE BLANK

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

SECOND CONTRIBUTION

TO THE

STUDIES ON THE CAMBRIAN FAUNAS

OF

NORTH AMERICA

BY

CHARLES DOOLITTLE WALCOTT

WASHINGTON

GOVERNMENT PRINTING OFFICE

1886

Charles Doolittle Walcott

ILLUSTRATIONS.

THIS PAGE BLANK

LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 15, 1886.

SIR: Herewith I have the honor to transmit the second of my preliminary studies on the Cambrian Faunas of North America. The larger portion of the report was ready for publication July 7, 1885, but, having visited a number of localities in Utah and Nevada during the season of 1885, numerous additions have been made to both the text and the plates.

Very respectfully,

CHARLES D. WALCOTT.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

THE CAMBRIAN FAUNAS OF NORTH AMERICA.

BY CHARLES D. WALCOTT.

INTRODUCTORY OBSERVATIONS.

§ 1. In using the name Cambrian in this paper for the series of strata characterized by the First or Primordial fauna of Barrande, I do not forget the claims of the name "Upper Taconic," which Dr. E. Emmons proposed for the strata now placed under the Middle Cambrian or Georgia Formation. At the end of these introductory observations the reader will find some remarks upon this subject which define my position at the present time.

§ 2. The term Cambrian is used from the belief that in so doing I approve of the view of those writers that hold that each of the distinguished authors, respectively, of the names Silurian and Cambrian will be fairly recognized, and geologic nomenclature advanced by the use of the names Cambrian and Silurian for the divisions of strata characterized by the first and third faunas as defined by Barrande. This is spoken of here as, in the second edition of Geikie's Manual of Geology, 1885, p. 651, the author has included the Cambrian as a subdivision of the Silurian system. I do not wish at this place to question the wisdom of this; but of the presence of a well defined geologic system beneath the strata characterized by the second fauna of Barrande or the Trenton fauna (including the Chazy and most of the Calciferous) *of North America, on the North American continent,* there is no question. The geologic sections given in this paper show it to have a total thickness of over 18,000 feet, and that its middle division has a known fauna of 43 genera, represented by 107 species. We also know that the Lower Cambrian or Paradoxides fauna has 32 genera and 76 species; that the Upper Cambrian or Potsdam fauna includes 52 genera and 212 species; that of the 393 species now known from Cambrian rocks but very few pass up into the Calciferous horizon of the Lower Silurian (Ordovician); and that the faunas of the two systems are so distinct in their general facies, and also in detail, that they are quite as readily separated as the Silurian and the Devonian or the Devonian and the Carboniferous. There is no doubt that in certain areas the faunas of the Cambrian and the Lower Silurian (Ordovician) systems are intermingled; but the same is more or less true of all the great divisions of the entire geologic series from above the great Archean break to the Quaternary.

§ 3. A good illustration of the mixing of the Upper Cambrian and the Lower Silurian (Ordovician) faunas is shown in the Eureka section of Nevada, in the fauna described by M. Barrande from the environs of Hof, in Bavaria, and still better in the Tremadoc of Great Britain; but all this mixing, at the boundary line, does not prevent the recognition of the first and second faunas, as such, either above or below the ho rizon where the great change in the faunas took place.

REVIEW OF THE STRATA AND FAUNAS REFERRED TO THE MIDDLE CAMBRIAN OR GEORGIA HORIZON.

§ 4. I have long been of the opinion that the paleontologist should become personally acquainted with the strata containing the faunas he is to study, and, as far as it is practicable, collect the fossils or superintend their collection in order to learn their exact stratigraphic relations to the geologic section and their relative position to each other in the section; but, in the study of the enormous thickness of strata in the Rocky Mountain Paleozoic, it has often been impracticable to carry out the work in the degree of detail that is desirable. I have, however, studied in the field most of the sections mentioned in this article, and know from which horizons the collections were obtained, and therefore with considerable confidence express conclusions that differ from those reached by geologists and paleontologists who have arrived at their results through the accounts of the observations and collections of others or from stratigraphic or paleontologic data considered without giving due weight to the importance of combining them.

§ 5. While not desiring, at this time, to enter into a general discussion of the stratigraphy and paleontology of the Cambrian System as a whole, it appears desirable to present sufficient evidence to show that the Potsdam and Georgia horizons are well-defined stratigraphic divisions and distinguished by large and distinct faunas in the same geographic area and geologic sections.

§ 6. The stratigraphy of the Cambrian System of North America has not been well known up to a comparatively recent date, and the extent and the character of its organic record are not yet appreciated. Dana's Manual of Geology, edition of 1881, p. 163, places the Cambrian as a subdivision of the Lower Silurian, as follows:

I. Primordial or Cambrian Period. (2)

1. Acadian Epoch (*2a*). Shale and sandstone at St. John, New Brunswick, the St. John group of Matthew and Logan, the Acadian group of Dawson; beds at St. John's and elsewhere, in Newfoundland; clay-slate and silicious slate of Braintree, Mass.; Ocoee conglomerate and slates of East Tennessee and North Carolina.

I. Primordial or Cambrian Period—Continued.

2. Potsdam Epoch (2*b*). Sandstone of Potsdam and other places in Northern and Northeastern New York, Western Vermont, and Canada; sandstone and limestone of Troy, N. Y.; slate and limestone of Northwestern Vermont, including the Georgia shales; limestone and sandstone of shores of the Straits of Belle Isle; Chilhowee sandstone of East Tennessee; sandstone with some limestone in Wisconsin and Minnesota.

§ 7. On paleontologic evidence, Prof. R. P. Whitfield (Bull. Amer. Mus. Nat. Hist., vol. i, p. 140, 1885) correlates all the Cambrian faunas, practically ignoring the stratigraphic evidence then published. He says:

My own impression, at the present time, is that the New York typical Potsdam is about equivalent to the lower portion of the Wisconsin areas, and that the Acadian beds of Canada and Vermont, and perhaps the other Atlantic areas, are not appreciably different in age, but that the difference in faunæ is more the result of conditions upon which life depended than a difference in time.

§ 8. Dr. T. Sterry Hunt has been a strong supporter of the view that the Cambrian System exists in North America as a system distinct from the Lower Silurian (Ordovician), and advocates the use of the name Ordovician of Lapworth in place of Lower Silurian and the retention of the term Cambrian for the strata of the first fauna. He placed the Upper Taconic of Emmons in the Cambrian and gave a table showing the nomenclature and classification of North American rocks (Can. Rec. Sci., vol. i, p. 81, 1884).

§ 9. The accompanying observations on the geologic sections of a portion of the Cambrian System and their contained faunas are also given that the student may know the data upon which the writer proposed dividing the Cambrian system of North America into subdivisions in 1883 (Cambrian Syst. U. S. and Canada; Bull. Phil. Soc. Washington, vol. vi, p. 98, 1883).

We will begin with an examination of the Western Vermont sections of the borders of Lake Champlain, where the Georgia Formation first yielded a portion of its characteristic fauna.

GEORGIA FORMATION.

§ 10. The history of the Georgia Formation as we find it in the Geology of Vermont, vol. i, pp. 357–8, 374, 1861, is as follows:

Primitive Argillaceous Slate: Prof. Chester Dewey's Geological map of Berkshire, Mass.; Columbia and Rensselaer Counties, New York; American Journal of Science and Arts, 1st ser., vol. viii, 1824.

Primitive Argillaceous Slate: Geological Report of Massachusetts, 1832.

Black Slate and Taconic Slate: Roofing slate of the upper part of the Taconic System; Prof. E. Emmons's works on the Taconic System, 1840–1860.

Hudson River Group or Lorraine Shales: Geological map of New York, 1842; also in the Paleontology of New York, vol. i, by Prof. James Hall, 1847.

"*Roofing Slate of the Taconic System,*" *but considered as of the Hudson River Group:* Reports on the Geology of Vermont, 1845–1847, by Prof. C. B. Adams.

Upper part of the Hudson River Group, or a distinct group above the Hudson River Group: Quoted by Prof. James Hall, from the opinions of Sir William E. Logan; Twelfth Annual Report of the Regents of the University of the State of New York, 1859.

Upper Hudson River Group: Elementary Geology, thirty-first edition, p. 411; by Edward Hitchcock and C. H. Hitchcock, 1860.

Slates containing the First Fauna, or the Primordial Zone of Life: Letter from M. Joachim Barrande to Professor Bronn, of Heidelberg, July 16, 1860.

Belonging to the Primordial Zone of Life, and perhaps the equivalent of the Potsdam Sandstone: Letter from Sir William E. Logan to M. Joachim Barrande, January 3, 1861.

We use the term *Georgia Group* to designate this terrain from the town of Georgia in Franklin County, Vermont, where it is developed in its full proportions and where the most interesting fossils have been found. It is a name also which does not involve any theory and may be used by both parties in the controversy respecting its age.

The name of *Georgia Group* or *Georgia Slate* is given to this group of rocks rather than any other, such as *Fairhaven Slate* or *Castleton Slate*, because it is a purely geological designation and has no reference to the economical value of the slate. Two reasons may be given for the preference of Georgia: First. The whole of the group is developed in the town of Georgia, but is not in either of the others mentioned. It is a rule of geological nomenclature that the whole series of rocks must be developed in the town, mountain, or along the river from which the name is derived. Second. Nowhere but in Georgia, in Vermont, are the characteristic fossils of the group displayed. They have as yet been found only in the New York portion of the southern terrain. The geological character of the group is best developed in Georgia, and we are therefore compelled to use the name of this town in describing the slates geologically.

Lithological characters.—The Georgia slate includes all the following varieties of rock:

1. Clay slate.
2. Roofing slate.
3. Clay slate, approximating to micaceous sandstone.
4. Various kinds of limestone.
5. Brecciated limestone.
6. Conglomerate, composed of pebbles of limestone.

The Georgia slate includes what Professor Emmons has ranked as the black slate, Taconic slate, and roofing slate; and yet not altogether, for we have regarded all the black slate beneath the red sandrock as belonging to the Hudson River Group. The characteristic trilobites of the Georgia slate are represented by Emmons in his *Taconic System*, 1844, as found in the black slate.

There are three views respecting the age of the Georgia slate:

(1) Professor Emmons says it is the uppermost member of the Taconic System and that the Taconic System is stratigraphically below the Potsdam sandstone—that is to say, that the Taconic System is Cambrian. Upon pages 90, 91, of Part V of American Geology, the Taconic System is directly compared with the Skiddaw slates of Cumberland. In opposition to this view, we would say that the Georgia slate rests conformably upon the Red Sandrock series, as is shown in Fig. 257, and its fossils rank it as Lower Silurian rather than Cambrian.

(2) M. Barrande and Sir W. E. Logan, judging from paleontological evidence, regard the Georgia slate as equivalent to the Primordial Zone C of Bohemia, or very nearly the Potsdam sandstone of North America. * * *

(3) The stratigraphical view of the Georgia slate, which has been so ably defended by Professor Hall, seems to demand for it a place either above or equivalent to the Oneida conglomerate.

§ 11. As we now know the Georgia Formation, it appears that Dr. Emmons was correct in placing it below the Potsdam sandstone, as was also done by Mr. Billings and later writers.

§ 12. The typical Georgia Formation, as developed in the town of Georgia, Franklin County, Vermont, consists, as seen at the base, of a great thickness of magnesian limestones that pass, in their upper portions, into an arenaceous magnesian limestone that is overlaid by a belt of arenaceo-argillaceous shales, and this by a great thickness of a purer argillaceous shale that, high up, carries a brecciated limestone conglomerate and lenticular masses of sandstone and limestone, from the size of a bean to masses 2,000 feet in thickness and several miles in superficial area.

§ 13. A carefully measured section (fig. 1, page 16), beginning at the base of the westward-facing cliff overlooking the level that reaches to the shore of Lake Champlain, and extending southeastward through Parker's quarry, and a little south of Georgia post office, gives the following:

	Feet.
1. Massive-bedded, bluish-gray dolomitic limestone with many inosculating threads and bunches of a yellowish-drab sandy limestone that weathers in relief	35
2. No. 1 passes into a steel-gray dolomitic limestone that weathers to a dark buff and bluish black, with angular fragments of bluish-gray limestone appearing irregularly at the surface. At 160 feet from the base the first band of mottled limestone, "Calico" or Winooski marble, is met with. The latter grades into a reddish dolomite free from mottling, and then in a gray limestone. (Fossils: Hyolithellus?)	200
3. Gray dolomitic limestone in massive layers, some of which are mottled, reddish and white, but the larger part are gray and yellow. Many of the gray layers break up into a columnar structure, the columns being at right angles to the bedding. In a reddish-colored limestone, 200 feet from the base, a slender elongate tube occurs, probably *Hyolithellus micans*	475
4. Reddish-pink dolomitic limestone weathering to a reddish brown and decomposing, on the exposed edges, to an arenaceous, dark, brownish-red rock that shows numerous fragments of fossils: *Kutorgina Labradorica*, *Obolella* (?) sp., *Salterella pulchella* (?), *Ptychoparia Adamsi*, *Olenellus Thompsoni*	100
5. Gray arenaceous limestone in rough massive layers, passing into more evenly bedded light-gray arenaceous limestone. Fossils similar to those in 4 occur in the lower portion	190
Total thickness of limestone	1,000
6. *Georgia shales.*—Argillaceo-micaceous and arenaceous shales containing numerous fossils at Parker's ledge and showing deposition contact on No. 5. Strike at Parker's quarry N. 30° E., dip 8° to 12° E.	200
The fossiliferous shales at Parker's quarry contain: *Palæophycus incipiens*, *P. congregatus*, *Diplograptus* (?) *simplex*, *Climacograptus* (?) *Emmonsi*, *Kutorgina cingulata*, *Orthisina Orientalis*, *O. festinata*, *O. transversa*, *O.* sp. (?), *Microdiscus Parkeri*, *Mesonacis Vermontana*, *Olenellus Thompsoni*, *Olenoides Marcoui*, *Bathynotus holopyga*, *Ptychoparia Adamsi*, *P. Vulcanus*, *Protypus Hitchcocki*, *P. senectus*, and *P. senectus* var. *parvulus*.	
7. East of the Parker quarry the rocks are argillaceous shales with occasional layers of hard gray limestone, one-half of an inch to two inches thick, that carry numerous fragments of a linguloid shell	3,500
Strike of shales near top of 7 N. 40° to 60° E., dip 60° S. E.	
8. Light-gray quartzite	50

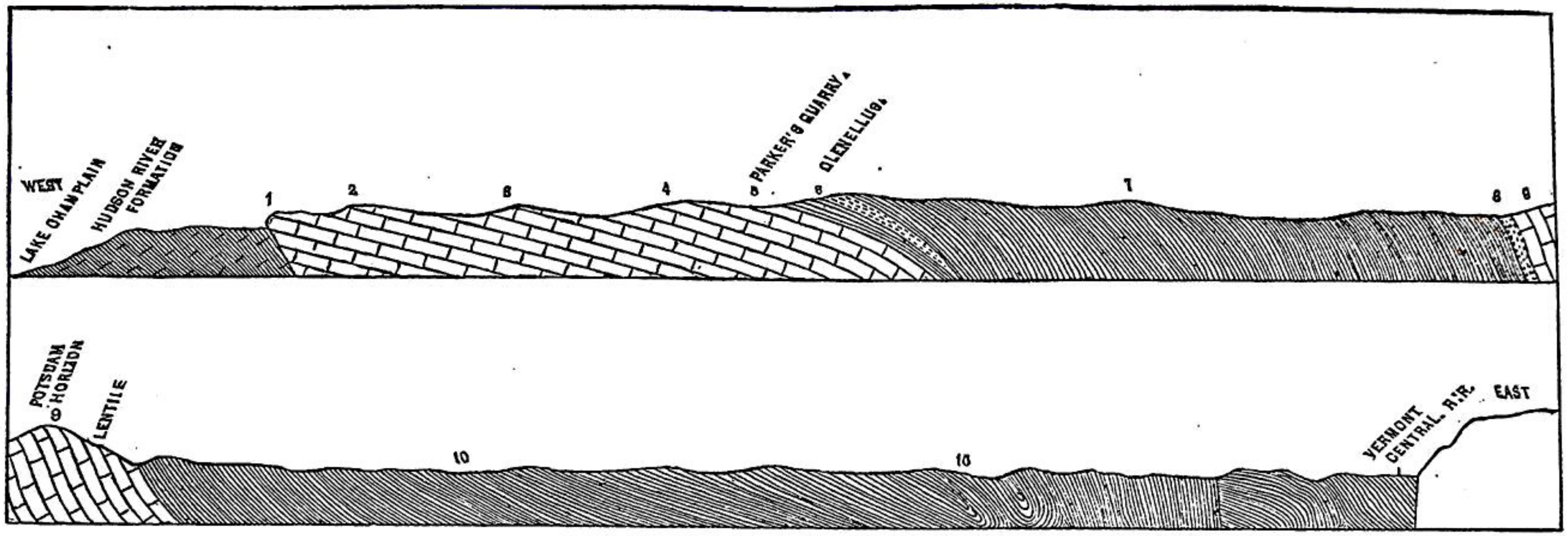


FIG. 1.—Georgia section. This extends from Lake Champlain east to the Vermont Central Railroad track, and passes through the Parker trilobite quarry, and a little south of the town of Georgia post office. Horizontal scale, about 2,000 feet to the inch.

The figures 1 to 10 indicate the position of the lower strata of each of the divisions given in the descriptive section.

Feet.

9. Gray limestone in massive layers, with occasional intercalated bands of hard argillaceous shale similar to that beneath the limestone. Many of the beds of limestone appear to have been broken up into fragments and recemented in situ.......... 1,700

Average strike of limestone beds N. 50° E., dip 50° to 90°, average dip 60° S. E.

In this limestone belt, one mile north of where the section crossed, a few fossils were found: *Lingula*, n. sp., *Orthisina* undt. (fragment), Camarella undt. (probably new), Agnostus like *A. Orion*, and Ptychoparia like *P. Adamsi*.

10. Argillaceous shales, very similar to those in the Parker ledge, continue on up to the opposite side of the line of the Vermont Central Railroad track. At the base the shales rest conformably against the limestone of 9, and above appear to be cut off by a fault.

Strike N. 50° E., dip 60° to 80° S. E. for a distance beyond the limestone; the dip then decreases and does not exceed 20° for a long distance, until within 1,000 feet of the railroad rack, where the shales become coarser and changed by addition of arenaceous material and the dip increases.

Total thickness to fault line of No. 10, 3,500 to 4,500 feet.

§ 14. No. 8 of the section when traced on its strike to the southwest increases in force very rapidly to the thickness of 500 feet or more, and also changes from a quartzite to a more or less calcareous sandstone, containing irregular fragments of argillaceous shale. Followed to the northeast, it soon disappears and the limestones rest directly on the shales. Continuing northeast on the limestone (9), it is found to decrease rapidly, and a mile northeast of where it is over 1,500 feet in thickness the width across the outcrop is not over 150 feet, and soon the shales above it and those below it come together, the limestone having disappeared. Southwest of the line of the section the width of the outcrop narrows, and north of Georgia Plains post office the entire section is covered by beds of sand.

No. 9 appears to be a great lenticular mass of limestone (lentile of Marcou), with intercalated beds of argillaceous shale, and more rarely with arenaceous beds imbedded in the argillaceous shales. The fauna is Cambrian in character, and, in the absence of Olenellus and other typical Middle Cambrian fossils, approaches that of the Upper Cambrian or Potsdam sandstone.

§ 15. On Mr. Noah Parker's farm a lenticular mass of calcareo-arenaceous rock is exposed on the edge of the first cliff facing west, where trilobites are found: Olenellus, Bathynotus, &c. (6 of the section). The mass is small: 25 feet in thickness at the center and about 50 feet in diameter, as seen in the section. Erosion has removed most of the shale from above it, but in a second lenticular mass, just back of it, the shales may be seen resting over and against the upper side of the calcareo-arenaceous rock, and in the shales numerous small masses of a similar rock occur that are not over six inches in diameter. On the hill, still farther to the northeast, a hard calciferous sandrock occurs that appears to be a remnant of a different formation from the shales below; but a close study shows it to be a portion of a lenticular mass left by erosion, and resting conformably on the shales beneath, each dipping 10° eastward. Several other instances were observed where erosion had left these masses resting on the shales; and it was not until they were found to pass beneath the shales, to have portions of the shale still preserved on their upper surface, and to contain the same species of fossils as the shale, that the writer felt sure that they were not fragments of the later formation deposited on the Cambrian beneath. It is these masses that Prof. Jules Marcou referred to the Potsdam sandstone (Bull. Soc. Géol. de France, 3e sér., t. ix, p. 24, 1880). In a letter to the writer, dated December 26, 1885, Prof. Marcou states that the sandrock at Parker's quarry was referred, *by error*, to the "Red Sandrock or Potsdam Sandstone," as his field notes of 1861 place it in the Georgia series as a "lentile."

§ 16. A section taken east of Highgate Springs, beginning on the line of the same fault as the Georgia section, gave a slightly greater thickness and also more arenaceous matter in the limestone series beneath the Georgia shales.

The section begins on the east side of the road running from St. Armand, Canada, to Swanton, Vt., near the house of Eldad Stearns:

	Feet.
1. Compact gray silicious limestone in massive layers	20
2. Gray calciferous limestone, compact, hard, evenly bedded, breaking up into shaly layers in places. Some of the layers decompose on exposure into a reddish sandy rock	180
3. Compact purplish, pinkish, or greenish colored silicious limestone in massive layers	30
4. Thick layers of buff and pinkish-colored silicious limestone with fragments of *Ptychoparia Adamsi*	15
5. Heavy-bedded, reddish-purple, fine-grained magnesian limestone, breaking into angular fragments (*Ptychoparia Adamsi* in abundance) Strike N. 30° E., dip 25° to 28° E.	50
6. Shaly and massive layers of gray and purplish colored sandstones containing fragments of *Ptychoparia Adamsi*, occurring at various horizons	175
7. Reddish-colored arenaceous limestone, with irregularly bedded massive layers of gray silicious limestone and a few more-evenly-bedded layers carrying fossils: *Kutorgina Labradorica, Orthisina festinata, Orthisina sp.?, Scenella varians, Hyolithes sp.?, Salterella pulchella?, Olenellus Thompsoni, Ptychoparia Adamsi, Ptychoparia Teucer.* Layers of gray and buff sandstone also occur at intervals	700
Total	1,170
8. *Georgia shales.*—Argillaceous shale with interbedded masses of limestone, layers of sandstone, and silicious limestone. In the limestone, *Kutorgina cingulata, Orthisina festinata, Olenellus Thompsoni,* and *Ptychoparia Adamsi* occur	1,000
9. Heavy layers of silicious limestone, with layers of sandstone midway, extending about 100 feet	850

Average dip, 20°; distance, 2,500 feet. A fault line here cuts off the section.

§ 17. The section east of Swanton does not show as great a thickness of the limestone beneath the Georgia shales, and a fault line crossing the shales a little obliquely to the strike cuts out a portion of them. On the east side of the fault two or three hundred feet of shales occur, and then a layer of conglomerate limestone, the fragments of limestone varying in size from pebbles to masses six feet in diameter. The fossils in the limestone conglomerate have an Upper Cambrian aspect and include *Lingula* sp. ?, *Amphion* ? sp. ?, *Bathyurus* sp. ?, a fauna that may be compared to that obtained in *some* of the bowlders of the Point Levis conglomerate. Below the horizon of the conglomerate and in situ in the shales we found *Lingulella*, *Agnostus*, *Ptychoparia*, and *Solenopleura*. With the exception of the *Solenopleura* the species appear to be identical with those in the limestone "lentile" (9) of the Georgia section.

§ 18. A section taken east of Swanton by Sir William Logan (Geol. Canada, 1863, pp. 281, 282) gave 520 feet of the limestone series; by tracing the strata north nearly to the Canadian boundary, he found 1,410 feet in the section; another series north of the Province line gave 790 feet, making a total of 2,200 feet, part of which is estimated.

That this portion of the Georgia Formation thickens rapidly to the north there is little doubt; but, until further study is given to the correlation of the horizons in the different sections, I should hesitate in giving it a greater thickness than 1,500 feet within the limits of Vermont.

§ 19. The fauna of the Olenellus horizon east of Swanton gives *Kutorgina cingulata*, *K. Labradorica*, *Orthisina Orientalis*, *O. festinata*, *Camarella antiquata*, *Salterella pulchella* ?, *Olenellus Thompsoni*, *Ptychoparia Adamsi*, and *Protypus senectus*.

§ 20. The Georgia section is the most complete yet taken in Vermont. At the base the great belt of dolomitic limestone, 1,000 feet in thickness, rests against and, by a fault, overlaps the Trenton limestones of the Ordovician (Lower Silurian). What was originally beneath the limestone belt is yet undetermined.[1] In the Highgate section the limestone belt is nearly 1,200 feet thick. The base is unknown, and it does not appear, so far as I know, in the section between the boundary of the United States and Canada and the outcrops in the town of Georgia.

Following the Georgia section up, a great mass of argillaceous shales, 3,500 feet in thickness, occurs before the great "lentile" is reached; this adds 1,700 feet, and above it 3,500 feet of shales come in before a probable line of faulting is met with.

§ 21. East of the supposed fault line, which is indicated by the disturbed strata and a high ridge of hills, just east of the Vermont Central Railroad track, a great thickness of hard argillaceous shales or argillites occurs, in which no traces of organic life have been discovered to my knowledge. It may be that in taking the section eastward of Parker's quarry faults occur that have duplicated the thickness of the

[1] It may be that the great mass of shaly argillites east of the Vermont Central Railroad track, in the Georgia section, are older than the limestones at the base of the section; but until further evidence is obtained this is merely conjectural. (See § 13.)

shales, but, on each side of the great "lentile," deposition contacts were seen and no evidence of the presence of faults was observed. If this is actually the case, we have nearly ten thousand feet of strata that we know to be of Cambrian age by its contained fauna. Of this, I refer 4,500 feet to the Middle Cambrian or Georgia Formation, or 1 to 7, inclusive, of the Georgia section.

§ 22. The typical Georgia fauna, *Kutorgina cingulata*, *K. Labradorica*, *Olenellus*, *Mesonacis*, *Bathynotus*, *Ptychoparia Adamsi*, and *Protypus senectus*, is found in the upper portion of the great limestone series, in the sandy and argillaceous shales resting on it, and in the masses of interbedded calciferous sandrock which Prof. Marcou referred to the Potsdam. (See § 15.) How far this fauna extends up into the shales we do not know. One species, *Ptychoparia Adamsi*, is represented in the great "lentile" of the Georgia section; but I have drawn the provisional upper line of the Georgia Formation at the base of the "lentile," as it is here that we meet with a decided change in the fauna, and the deposit is unlike that found below. It will probably be found that the limestone conglomerate, east of Swanton, occurs at about the same relative horizon as the "lentile" of the Georgia section.

§ 23. In the group of sections, taken across New Hampshire and Vermont, by Prof. C. H. Hitchcock (Bull. Amer. Mus. Nat. Hist., vol. i, pls. 16 and 17, 1884) we find the Georgia series called Potsdam and Cambrian; and, in section XI, pl. 17, the Georgia shales (Cambrian of section) are represented as resting conformably on the magnesian limestones (Potsdam of section), in the town of Milton. This is the same as we found it in the Georgia section a few miles to the north; and the great "lentile" (8 and 9 of the Georgia section) corresponds in position to the mass of Cambro-Silurian limestone of Professor Hitchcock's section XI, except that it is represented as let into the shales by faulting. The Highgate section of Hitchcock, No. XIII, shows a fault between the limestone and the shales, but my section crossed where the succession was unbroken.

§ 24. The fauna of the Georgia shales is referred to the Lower Potsdam by Professors Whitfield and Hitchcock in the text accompanying the sections, but, as is shown in this paper, there is very little reason for longer retaining that name.

§ 25. The great mass of argillites, east of the railroad track, in the Georgia section, is placed under the Cambrian by Professor Hitchcock, and the reference may be correct; but, as yet, we have no recognized Cambrian fossils from it.

STRATIGRAPHIC RELATIONS OF THE GEORGIA TO THE POTSDAM SERIES.

§ 26. Across Lake Champlain from Vermont in New York the typical Potsdam sandstone rests against the Archean of the Adirondack Mountains. At the Au Sable Chasm there have been found *Lingulepis* *minima*, *Obolella prima*, *Palæacmea typica*, *Climactichnites sp.?* and *Ptychoparia minuta*. Following the sandstone south from Au Sable Chasm, it is seen outcropping all along the base of the mountains; at the Falls in the Hudson at Corinth, a good section is shown; in the town of Greenfield, Saratoga County, the calcareous layers begin to appear resting on the sandstone, and a little west of Saratoga Springs numerous fossils are found that correspond in character to the higher Potsdam sandstone faunas of Wisconsin; they are associated with others of a more distinctive type. The species now known are:

Cryptozoa proliferum.	Billingsia Saratogensis.
Lingulepis acuminata.	Matthevia variabilis.
Platyceras minutissimum.	Dicellocephalus Hartti.
Platyceras Hoyti.	Dicellocephalus speciosus.
Metoptoma cornutiforme.	Ptychoparia calcifera.
Metoptoma simplex.	Ptychoparia (A.) Saratogensis.

§ 27. This fauna was first noticed in a paper printed in advance of the Thirty-Second Annual Report of the New York State Museum of Natural History. It was there referred to the Calciferous horizon, January, 1879. The fauna was referred to as Potsdam in 1883 (Amer. Jour. Sci., 3d ser., vol. xxvi, p. 439, foot-note), and the reference to the Calciferous corrected in 1884 (Science, vol. iii, p. 136, February, 1884), and attention again called to the relations of the fauna to that of the Potsdam sandstone of Wisconsin, and a list of species given.

Prof. Jules Marcou refers to the latter reference and uses the data in his work on the "Taconic System and its position in Stratigraphic Geology" (Proc. Amer. Acad. Sci. and Arts, new ser., vol. xii, p. 222, 1885).

§ 28. The means of comparison now at hand show the Saratoga Potsdam fauna to be still more closely related to the Wisconsin Potsdam sandstone fauna.

NEW YORK.	WISCONSIN.
Cryptozoa proliferum	
Lingulepis acuminata	Lingulepis pinnæformis.
Platyceras minutissimum	Platyceras minutissimum.
Platyceras Hoyti	
Metoptoma cornutiforme	Metoptoma cornutiforme.
Metoptoma simplex	
Billingsia Saratogensis	
Matthevia variabilis	
Dicellocephalus Hartti	Dicellocephalus Pepinensis.
Dicellocephalus speciosus	Dicellocephalus Lodensis.
Ptychoparia calcifera	Ptychoparia Wisconsensis.
Ptychoparia (A.) Saratogensis	Ptychoparia Oweni (of Hall).

Platyceras minutissimum and *Metoptoma cornutiforme* occur at Osceola Mills, Wisconsin, and *Dicellocephalus speciosus* appears to be identical with *D. Lodensis*.

§ 29. The section, as determined north and west of Saratoga Springs and north as far as Corinth, New York, has, at the base, about 200 feet of evenly-bedded, compact, grayish to yellowish colored sandstone, that rests unconformably against or upon spurs or ridges of Archean gneiss. Including the upper beds of sandstone, the section three miles north of Saratoga village gives in ascending order:

	Feet.
1. Sandstone	40
2. Oölitic limestone	30
3. Dark-gray, evenly-bedded limestone	50
4. Unfossiliferous, impure, compact, more or less silicious limestone	95
5. Massive-bedded, slightly magnesian, gray and dove colored limestones with numerous small, narrow-chambered cephalopods near the summit	35
6. Massive layers of steel-gray, more or less arenaceous limestone	125
7. Bird's-eye limestone	6
8. Black River limestone	4
9. Trenton limestone	40+

§ 30. The passage from the Potsdam fossil-bearing limestone (3) of the section to the dove-colored limestones (5) carrying the cephalopods is through a considerable thickness of more or less impure, slightly arenaceous limestone that has been known as the Calciferous sandrock in this region, but at Rock City Falls the Bird's-eye limestone rests directly on similar beds, and from a study of the strata to the northeast, in the vicinity of Glens Falls, I am inclined to think that it is impossible to recognize, by lithologic characters, the Calciferous formation as distinct from the Chazy limestone horizon; and at Glens Falls *Maclurea magna* and great numbers of an Ophilita like *O. compacta* are found in the same stratum of rock but a little distance beneath the Trenton limestone, an occurrence that renders it very difficult to state what is to be assigned to the Calciferous horizon in this region and also in the valley of Lake Champlain, as our section at Chazy, N. Y., gave 700 feet of limestone with Chazy fossils to the base, where the limestone rested on the sandy, fucoidal layers just above the Potsdam sandstone. These fucoidal layers have been referred to the Calciferous on but very slight evidence.[1]

§ 31. The limestone (2, 3) capping the sandstone (1) of the section is also found at Whitehall and at Comstock's Landing, Washington County, New York, where it has been, as was the limestone (2, 3), referred to the Calciferous. The limestone 2 and 3 appears to have been, on the southwestern side of the Adirondack Mountains, the closing deposit of the Cambrian; and there is but little doubt that if we could find a fauna in the limestone (4) of the section it would serve to connect the Cambrian and Lower Silurian (Ordovician) faunas.

[1] This nonconformity by non-deposition, noticed by Logan, is nowhere better illustrated than in this section; the entire Calciferous or Phillipsburg formation, so near at hand, is absent. The same irregularity of deposits, indicating varying levels in the sea bed, is noticeable around the Adirondacks to the southern side.

§ 32. The beds 2, 3, 4 fill in, to a certain degree, the gap which exists between the Potsdam and the Chazy, in the Chazy section. In the Mohawk Valley, at Little Falls and at Fort Plain, the Chazy formation is absent, a considerable development of the Calciferous, 300 feet or more, filling in the space between the Archean and the Trenton (Bird's-eye limestone); the Potsdam and older Cambrian formations being absent except at the "Little Nose," on the New York, West Shore and Buffalo Railroad, Montgomery County, New York, where a band of decomposed gneiss and lenticular masses of shale, that occurs between the gneiss and Calciferous sandrock, is referred to the Potsdam horizon. (Prof. James Hall.)

§ 33. In the February number of the American Journal of Science (3d ser., vol. xxxi, pp. 125–133), Prof. W. B. Dwight describes a belt of limestone near Poughkeepsie, New York, containing fossils of the Potsdam fauna that, from the references made to them, appear to be identical with the fauna of the Saratoga Potsdam limestone, even to an identity of species. The limestone is described as over 300 feet in thickness, and 12 or more species of fossils have been recognized. This discovery is of great interest and importance, as it shows the presence of the Potsdam fauna of the Adirondack region 100 miles farther south and in the line of a series of sediments that, 50 miles north, carry the fauna of the Middle Cambrian. The inference is plain that we may expect to find the two faunas in the same section, somewhere along the line of the Upper Taconic of Emmons.

§ 34. From what has already been given, it is evident that the Potsdam formation has not been observed by the writer in Northern Vermont as it exists in New York, but the inference is that the upper members of the Georgia section, or those carrying the lenticular and brecciated masses of limestone, are near the Potsdam horizon, or, as Sir William Logan said, in speaking of the equivalents of the Potsdam (Geol. Canada, 1863, p. 235), "out in deep water the deposit may have been a black, partially calcareous mud, such as would give rise to the shales and limestones which come from beneath the Quebec group." This view is illustrated by the ideal diagrammatic section, fig. 2, page 25.

§ 35. Accepting the conclusion that the matrix of the conglomerates at Point Levis is of Calciferous age, which was Sir William Logan's view, as expressed on page 233 of the Geology of Canada, the above view of the origin of the Georgia shales and the included calcareous beds, and their equivalency to the Potsdam Sandstone, is, to a certain extent, correct; the error consisted in considering the entire deposit as equivalent to the Potsdam, whereas it appears from the faunas that the limestone series of the Georgia Formation, including the "Winooski marble" and "Red sandrock," was a deposit antedating the Potsdam Sandstone of the New York series; that a considerable portion of the Georgia shales also antedated the latter, and that strata of an age equivalent to the Potsdam Sandstone were deposited in a continuous series, and conformably on the deposits beneath. Such appears to be the deduction from the Georgia, Swanton, and Highgate sections when compared with those of the Potsdam about the eastern and southeastern base of the Adirondack Mountains.

§ 36. The view expressed by the section, fig. 2, page 23, is that there was a practically conformable deposition of sediments, against and over the Archean area of the Adirondack Mountains, from early Cambrian times up to the close of the deposition of the sediment forming the Utica shale, except in the case of the unconformity by non-deposition between the Potsdam and the Chazy. The writer has seen the deposition contact of the Utica shale, against the granite, on the eastern side of the Adirondack Mountains, in Essex County, New York, and takes that as the upper line of the ideal section, although he has little doubt that the formations overlying the Utica shale, even through the Silurian, were deposited against and over the Archean of the Adirondacks and subsequently removed by denudation. Numerous minor faults now bring the strata of the ideal section in various relations to one another, e. g., the Potsdam sandstone resting against the Chazy and the Trenton, as at Chazy, N. Y.; the limestone of the Middle Cambrian of the Georgia section thrust over on the Trenton series, &c.

§ 37. In Fig. 2, the Potsdam formation, near the Adirondacks, is represented as a sandstone; to the eastward, as an arenaceous argillaceous shale; and beyond, as an argillaceous slate with irregular masses of limestone (lentiles) and thin beds of limestone intercalated in the slate or shales. This succession shows shore, off-shore, and deeper water deposits. The Trenton, Chazy, and Georgia limestones are represented as deposited directly against the Archean. We know this was the case with the Utica shale, and it appears to point to the submergence of the Adirondacks in the vicinity of the contact observed in Essex County, so as to prevent the disintegration and deposition of the materials composing the Archean, the mud, forming the Utica shale, being deposited against the ledges of granite that were entirely below atmospheric or wave action.

ST. LAWRENCE VALLEY.

§ 38. The conglomerate limestones of Bic Harbor, St. Simon, and up the St. Lawrence to the island of Orleans, and thence southwest toward Lake Champlain, do not appear to have been derived from pre-existing strata where they were deposited, as appears to be the case with the brecciated limestone in the vicinity of Troy, N. Y., but to have been transported and deposited as a portion of formation of a later geologic age. Dr. Selwyn has shown this to be the case with the Point Levis beds which contain bowlders, some of which carry Georgia fossils, others Potsdam fossils, and others Calciferous fossils, the last being nearly contemporaneous with the matrix of the conglomerate, the noted graptolite-bearing shales.

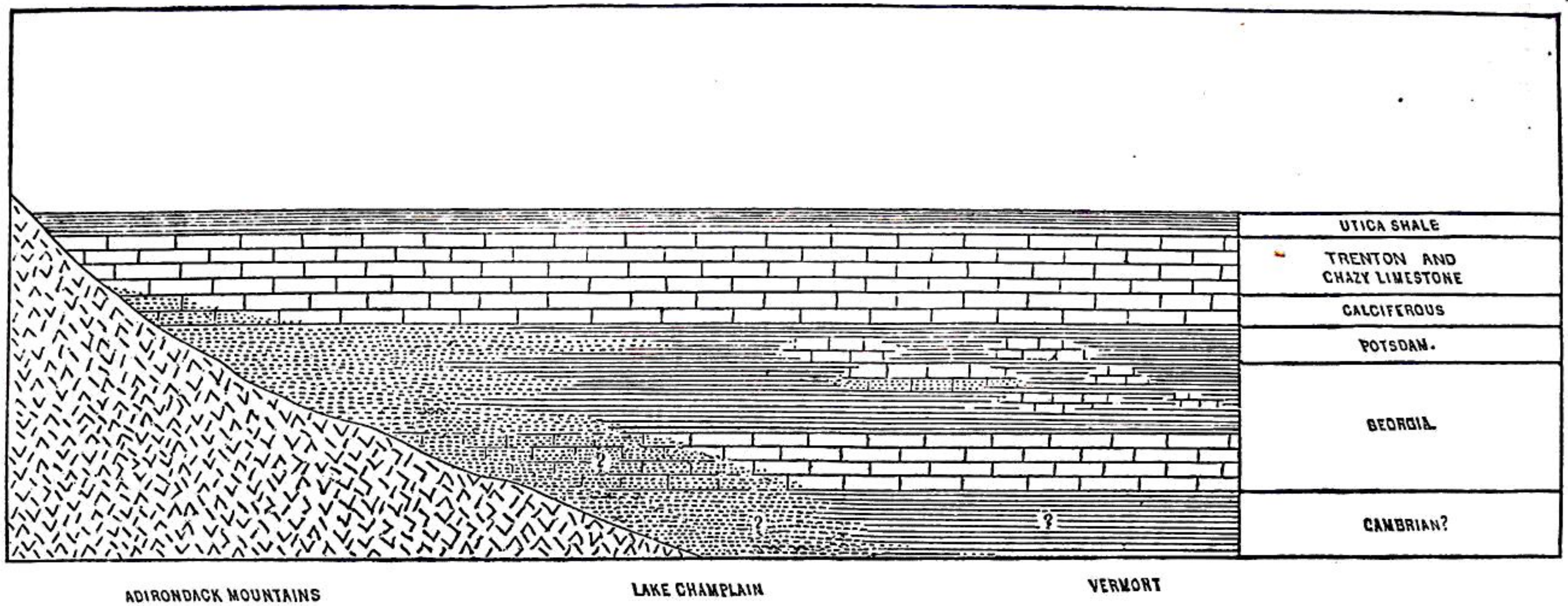


Fig. 2.—Ideal section, from the Adirondacks east over the line of the Georgia section, at the close of the deposition of the Utica Shales.

Lake Champlain is now situated over the area indicated by the position of its name, and the Georgia section, Fig. 1, page 16, is situated between the lake and the east end of the section on the right side of the figure. The division marked Cambrian? is unknown by actual observation on the line of the Georgia section, the Potsdam and Georgia Formations comprising the known Cambrian.

§ 39. Sir William Logan, in describing the section at Trois Pistoles, says: "At Trois Pistoles, in a section of 700 feet of strata, 150 feet at the base consist of gray calcareous sandstones and coarse limestone conglomerates, the latter comprising one-third of the amount, in nine separate layers of from two to sixteen feet thick. The matrix of the conglomerates is a gray calcareous sandstone; and the rounded masses imbedded in it, in addition to limestone, consist of quartz, and occasionally of amygdaloidal diorite. Of the limestone and the diorite, there are masses weighing from a pound to a ton, while the quartz pebbles seldom exceed an ounce." (Geol. Canada, 1863, p. 260.) This mode of occurrence compels us to refer to the faunas as from strata of which we have, as yet, no positive information.

§ 40. From Bic Harbor, Trois Pistoles, and St. Simon the following species have been found in the conglomerate limestone, as observed in the collection of the Canadian Geological Survey:

Lingulella cælata.	Agnostus sp. ?.
Iphidea bella.	Microdiscus lobatus.
Kutorgina cingulata.	Microdiscus speciosus.
Obolella crassa.	Olenellus Thompsoni.
Obolella Circe.	Olenoides Marcoui.
Obolella gemma.	Olenoides levis.
Orthis 2 n. sp.	Ptychoparia Adamsi.
Platyceras primævum.	Ptychoparia Teucer.
Scenella retusa.	Ptychoparia ? trilineata.
Stenotheca rugosa.	Ptychoparia sp. undt.
Hyolithes Americanus.	Ptychoparia (Agraulos) strenuus.
Hyolithes communis.	Protypus senectus.
Hyolithes princeps.	Protypus senectus var. parvulus.
Hyolithellus micans.	

§ 41. On the island of Orleans, Dr. Selwyn found in the conglomerate limestone:

Obolella crassa.	Ptychoparia Adamsi.
Orthisina sp. ?.	Ptychoparia Vulcanus.
Camerella sp. ?.	Solenopleura sp. ?.
Hyolithes Americanus.	Protypus senectus ?.
Hyolithellus micans.	Olenoides Marcoui.
Olenellus Thompsoni.	Olenoides levis.

§ 42. At Point Levis, Dr. Selwyn also discovered a pebble of limestone, in the conglomerate beds, filled with beautifully preserved specimens of *Salterella pulchella*.

TROY, NEW YORK.

§ 43. Passing to the locality which Mr. S. W. Ford has made so well known by his researches, we find that the conglomerate limestone is of the same geologic age as the limestones with which it is interbedded in the argillaceous shales, as both carry the same fauna; and the conglomerate is brecciated, although showing evidences of wear in most instances. The limestone appears to have been consolidated and then subjected to wave action. In some instances great masses of the evenly-bedded layers remain intact, while a little distance away they are broken up and buried in arenaceous and argillaceous sediments.

§ 44. The section as described by Mr. Ford (Amer. Jour. Sci., 3d ser., vol. ii, p. 33) consists, "for the most part, of coarse red and yellow weathering slates and shales, with occasional thin-bedded sandstones; but most of them are supposed, and four of them are known, to hold subordinate limestone deposits. Of these deposits the two westernmost individually consist of a few courses of thick-bedded limestone, and of irregular, sometimes lenticular, sparry and frequently pebbly masses, varying from one pound to several hundred pounds in weight, imbedded in a coarse, dirty-looking arenaceous matrix; while the others form tolerably compact even-bedded limestones, with an abundance of scattered black nodules, from 25 to 30 feet in thickness. The same species of fossils, with a few exceptions, have been found in both the even-bedded and conglomerate limestones."

§ 45. The following list is made from the species in Mr. Ford's collections and those of the United States Geological Survey:

Ethmophyllum rarum.
Ethmophyllum Rensselaericum.
Lingulella cælata.
Obolella crassa.
Obolella gemma.
Obolella nitida.
Orthis sp. ?.
Fordilla Troyensis.
Scenella retusa.
Stenotheca rugosa.
Platyceras primævum.
Hyolithes Americanus.
Hyolithes communis.
Hyolithes communis var. Emmonsi.
Hyolithes impar.
Hyolithes sp. ?.
Hyolithellus micans.
Leperditia Troyensis.
Agnostus nobilis.
Microdiscus speciosus.
Microdiscus Meeki.
Microdiscus lobatus.
Olenellus asaphoides.
Ptychoparia trilineata.
Solenopleura Nana.

§ 46. South of Schodack Landing, in Columbia County, New York, Mr. Ford obtained a better section than at Troy (Amer. Jour. Sci., 3d ser., vol. xxviii, p. 36). The base is cut off by a fault and the upper limits are unknown. It shows the varied character of the strata and the position of the brecciated limestone (in 7 of section), carrying twelve species of fossils identical with those at Troy, viz:

Palæophycus incipiens.
Lingulella cælata.
Obolella crassa.
Stenotheca rugosa.
Hyolithes Americanus.
Hyolithes impar.
Hyolithellus micans.
Fordilla Troyensis.
Microdiscus lobatus.
Microdiscus speciosus.
Olenellus asaphoides.
Ptychoparia trilineata.

The following is the section measured by Mr. Ford:

8. Bluish-gray slate, about	10 feet.
7. Even-bedded limestone, becoming brecciated at top	5 feet.
6. Green calcareous slate	10 feet.
5. Reddish quartz rock	9 inches.
4. Green calcareous slate	6 inches.
3. Reddish quartz rock	1 foot.
2. Dark-blue compact limestone, in regular courses, with slight shaly partings	13 feet.
1. Bluish-gray slate	80 feet.
Total thickness about	120 feet.

Two species are known from No. 2, *Lingulella cœlata* and *Microdiscus speciosus*, and *Hyolithellus micans*? occurs in No. 1.

§ 47. A section that I hurriedly examined with Mr. S.W. Ford, on Kinderhook Creek, above Stockport, Columbia County, New York, gives a greater thickness than the sections to the north, and is more like the sections given by Dr. Emmons as occurring in Washington County, New York.

All the thicknesses are estimated from the base up:

	Feet.
1. Greenish-drab argillaceous or silico-argillaceous shale	2,000
2. Gray limestone, evenly bedded, shaly, and also brecciated	50
3. Bluish-gray silico-argillaceous shale, with compact arenaceous layers at irregular intervals	800
4. Evenly-bedded and brecciated limestone, with *Olenellus* and *Lingulella cœlata*.	25
5. Dark and grayish shale, changing into slaty shale towards the summit	1,200
	4,075

The section shows the *Olenellus* horizon underlaid by a great thickness of shaly beds and that the massive limestone of the Georgia section is absent at this point. It is dangerous, however, to correlate in this way, as the shales may have been deposited to a much greater thickness than to the north in Vermont and the *Olenellus* fauna given a greater vertical distribution.

§ 48. Stratigraphically we cannot now connect the sections of Franklin County, Vermont, and those of Eastern New York with those of the Straits of Belle Isle or Newfoundland. I think it is only a question of careful field work to connect the Vermont and New York sections; the Vermont section will probably be traced northward into Canada, and the source of the conglomerates of the island of Orleans, Bic Harbor, &c., discovered. The presence of almost similar conglomerates in the Troy section, in connection with evenly-bedded strata carrying the same fauna, points to one condition under which the conglomerates may occur, but it is hazardous to consider that this is the method of its origin along the St. Lawrence, as at Point Levis, where the débris derived from three geological formations was buried in a common matrix.

NEWFOUNDLAND.

§ 49. As we have already noticed, the Georgia fauna is found in the vicinity of Quebec, Canada, and eastward along the south shore of the St. Lawrence River, in conglomerates of a later group; but at Bonne Bay on the west coast, L'Anse au Loup on the north side of the Straits of Belle Isle, and at Topsail Head, the extreme eastern locality, near St. John's, it occurs in situ. The Topsail Head locality has not been thoroughly worked, but I recognized, in the collections of the Canadian Geological Survey:

Scenella reticulata.
Stenotheca rugosa.
Iphidea bella.
Protypus senectus var. parvulus.

Of these *Stenotheca rugosa* and *Protypus senectus* are found at L'Anse au Loup, and Bic Harbor, below Quebec.

§ 50. The section given by Logan (Geol. Canada, 1863, pp. 865–867) of the strata holding the Georgia fauna at Bonne Bay gives over 2,000 feet in thickness; but, as the section was not taken by him and as there is confusion in relation to the fossils collected from it, a doubt remains as to its value. The species mentioned (Geol. Canada, 1863, p. 866) include *Kutorgina Labradorica*, *Obolella chromatica*, *Salterella* sp., *Olenellus* sp.? *Ptychoparia* sp.? Reference is made to a species of Bathyurus like *B. extans*, and, from an examination of the specimens and also associated fossils, I have no doubt that it is *Bathyurus extans* of the Trenton. The other species mentioned I did not see when looking over the collection of the Geological Survey of Canada. The section at L'Anse au Loup, as given in the Geology of Canada, p. 288, shows 231 feet of arenaceous beds at the base, overlaid by 143 feet of gray, reddish, and greenish limestones. I recently examined the collections from these limestones, now in the Canadian Geological Survey collection, and found the following species, most of which had been recognized and described by Mr. Billings:

Palæophycus incipiens.
Ethmophyllum profundum.
Archæocyathus Atlanticus.
Archæocyathus Billingsi.
Iphidea bella.
Kutorgina cingulata.
Kutorgina Labradorica.
Obolella chromatica.
Orthis, 2 sp.
Stenotheca elongata.
Stenotheca rugosa.
Hyolithes Billingsi.
Salterella pulchella.
Salterella rugosa.
Olenellus Thompsoni.
Ptychoparia miser.
Protypus senectus.
Solenopleura (like S. Nana).

§ 51. In passing from the eastern to the western side of the continent the Georgia horizon is not met with, as far as known, until we reach into the heart of the Rocky Mountains, in the great Wasatch Range of Utah.

Prof. N. H. Winchell has described *Paradoxides Barberi* from so-called Potsdam strata (Geol. and Nat. Hist. Survey Minnesota, Thirteenth Ann. Rep., 1885, p. 67), but after examining the specimen I am led to doubt whether it is organic at all; even if it were, the reference to the genus is conjectural, as such a trilobite might belong to the genus *Olenellus*, *Olenoides*, *Dicellocephalus*, or even *Crepicephalus*, as we have specimens of the latter from the Potsdam of Alabama 20 centimeters in length, including terminal spines of the *pygidium*. The brachiopod from the Catlinite quarry, described as *Lingula calumet*, looks very much like an *Obolella*. It is therefore evident that the fossils of the Catlinite beds do not fix the geologic horizon so that we can correlate them, although the section is much like that of the Grand Cañon of the Colorado, and the Catlinite beds are probably Pre-Cambrian. Geographically, we should speak of the Wasatch section first, but, as the section and fauna are more thoroughly known in Nevada, that area will now be considered.

NEVADA.

§ 52. The Georgia horizon, in the Cambrian section of the Eureka mining district of Central Nevada, is shown in the accompanying section, taken from Mr. Arnold Hague's Report on the Geology of the Eureka District, p. 253 (Abstract in Ann. Rep. Director U. S. Geol. Survey, 1881–'82):

[Cambrian, 7,700 feet.]

5.	Hamburg shale	350	Yellow argillaceous shale; layers of chert nodules throughout the bed, but more abundant near the top.
4.	Hamburg limestone	1,200	Dark-gray and granular limestone; surface weathering, rough and ragged; only slight traces of bedding.
3.	Secret Cañon shale	1,600	Yellow and gray argillaceous shales, passing into shaly limestone near the top; interstratified layers of shale and thinly bedded limestones.
2.	Prospect Mountain limestone	3,050	Gray compact limestone, lighter in color than the Hamburg limestone, traversed with thin seams of calcite; bedding planes very imperfect.
1.	Prospect Mountain quartzite	1,500	Bedded brownish-white quartzites, weathering dark brown; ferruginous near the base; intercalated thin layers of arenaceous shales; beds whiter near the summit.
	Total section	7,700	

§ 53. At the summit of 1 the quartzite becomes more thinly bedded and passes into an arenaceous shale which is more or less calcareous and, in its extension northward, is replaced by limestone. This belt of

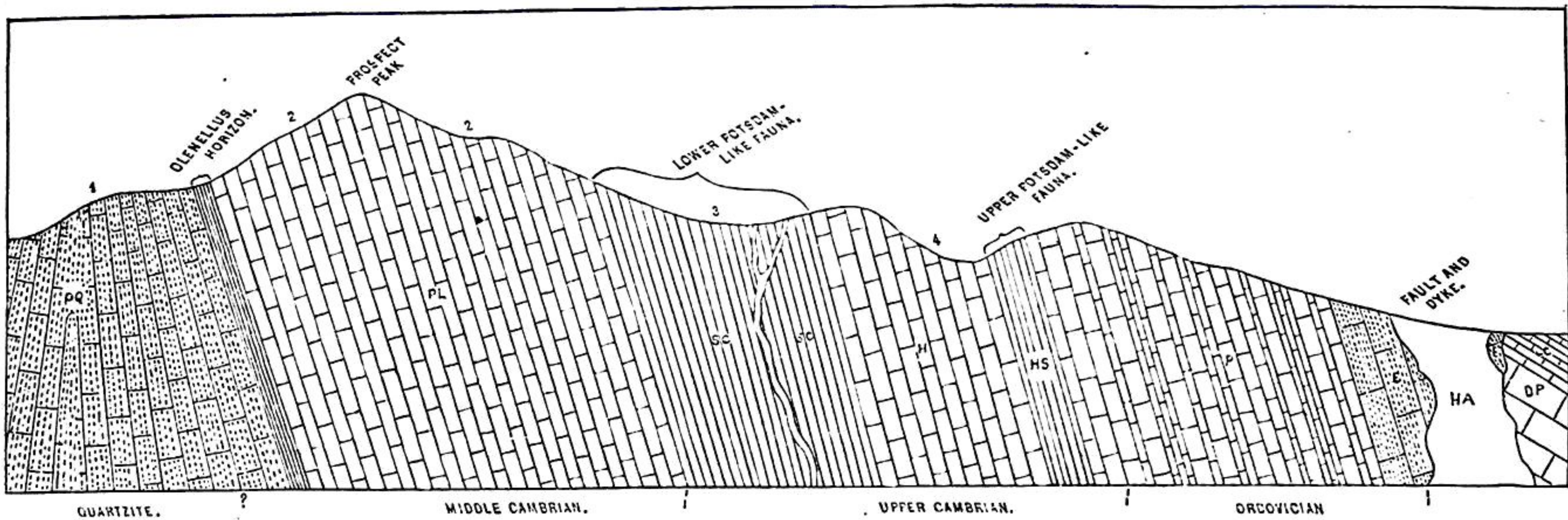


FIG. 3.—Eureka section. This extends over the Cambrian strata of the Eureka district and up to the base of the Trenton limestone horizon of the Lower Silurian (Ordovician).

The numbers on the upper line correspond to the numbers on the divisions given in the descriptive section: 1 and PQ. Prospect Mountain quartzite; 2 and PL, Prospect limestone; 3 and SC, Secret Cañon shale; 4 and H, Hamburg limestone; HS, Hamburg shale; P, Pogonip limestone; E, Eureka quartzite; HA, hornblende-andesite; LC, Lower Carboniferous; DP, Devonian.

The dike represented in the Secret Cañon shale is not continuous, and on the line upon which the fossils were collected it was not observed, the section being unbroken from 1 to the great dike beyond the Eureka quartzite.

The section is copied from the unpublished map of sections, by Mr. Arnold Hague, illustrating the Geology of the Eureka district. Scale, 1,800 feet to the inch.

shale and limestone is from 100 to 200 feet in thickness and carries numerous fragments of fossils, among which we have determined six species, viz: *Kutorgina Prospectensis*, *Scenella conula*, *Olenoides quadriceps*, *Olenellus Gilberti*, *O. Iddingsi*, *Anomocare parvum*, and *Ptychoparia* sp. ?

§ 54. The Prospect Mountain limestone is practically a continuation of the limestone of the upper portion of No. 1, and 500 feet up in it we find, in a band of shale, *Scenella conula*, *Agnostus interstrictus* ?, *Olenoides quadriceps*, *Ptychoparia Prospectensis*. All but the last are closely related to species from the Georgia horizon, in either Vermont or Canada. One other species, *Stenotheca elongata*, which is found associated with *Olenellus Thompsoni*, *Protypus senectus*, &c., at L'Anse au Loup, is found 2,000 feet higher up in the limestone. Another species, *Olenoides spinosus*, is found in association with species characteristic of a lower horizon than the typical Potsdam of Eureka, at Pioche, Nevada.

§ 55. Within a short distance of the summit of the limestone (2) we found a fauna that is more readily referred to the Upper Cambrian or Potsdam horizon, although *Stenotheca elongata*, *Protypus senectus*, and *Olenoides spinosus* are elsewhere found in the Middle Cambrian. This fauna includes representatives of both the Georgia and the Potsdam faunas, and is, in a measure, the passage fauna between them. The species are:

Obolella (like O. pretiosa).
Lingula manticula.
Kutorgina Whitfieldi.
Orthis Eurekensis.
Stenotheca elongata.
Agnostus communis.
Agnostus bidens.
Agnostus Neon.
Agnostus Richmondensis.
Protypus senectus.
Protypus expansus.
Dicellocephalus ? nasutus.
Ptychoparia Oweni.
Ptychoparia Haguei.
Ptychoparia occidentalis.
Ptychoparia dissimilis.
Olenoides spinosus.

§ 56. At the summit of No. 3 the fauna is without traces of the species found in the Olenellus horizon at any known locality. It includes:

Protospongia fenestrata.
Lingulepis Mæra.
Lingulepis minuta.
Lingula ? manticula.
Iphidea depressa.
Acrotreta gemma.
Kutorgina minutissima.
Hyolithes primordialis.
Agnostus communis.
Agnostus bidens.
Agnostus Neon.
Agnostus seclusus.
Dicellocephalus ? nasutus.
Dicellocephalus Richmondensis.
Ptychoparia pernasuta.
Ptychoparia laticeps.
Ptychoparia bella.
Ptychoparia Linnarssoni.
Ptychoparia Oweni.
Ptychoparia Haguei.
Ptychoparia similis.
Ptychoparia unisulcata.
Ptychoparia læviceps.
Chariocephalus tumifrons.
Ogygia ? problematica.

§ 57. Seven of the species pass up from the top of No. 2 and unite with five more from No. 3 and pass to the summit of the Upper Cambrian or Potsdam horizon in No. 5 of the same section.

In No. 5 we find:

Lingulepis Mæra.
Lingulepis minuta.
Lingula ? manticula.
Obolella discoidea.
Acrotreta gemma.
Kutorgina minutissima.
Agnostus communis.
Agnostus bidens.
Agnostus Neon.
Agnostus prolongus.
Agnostus tumidosus.
Agnostus tumifrons.
Dicellocephalus ? nasutus.
Dicellocephalus angustifrons.
Dicellocephalus Marica.
Dicellocephalus bilobus.
Dicellocephalus Osceola.
Ptychoparia affinis.
Ptychoparia Oweni.
Ptychoparia Hagnei.
Ptychoparia granulosa.
Ptychoparia simulata.
Ptychoparia unisulcata.
Ptychoparia breviceps.
Arethusina Americana.
Ptychaspis minuta.

Three of these species, *Hyolithes primordialis*, *Dicellocephalus Osceola*, and *Ptychaspis minuta*, are identical with forms from the Potsdam sandstone of Wisconsin.

§ 58. The above section and details are given to show the relation of the Georgia, or Olenellus, to the Potsdam horizon. The section of 7,700 feet of strata is continuous and entirely visible throughout its extent, as it forms the summit and eastern slope of Prospect Peak and crosses the Hamburg ridge. Hammer in hand I examined it, and collected fossils at all places where they could be found. The Olenellus horizon is separated by 3,000 feet of limestone from a fauna that can be correlated with the Potsdam fauna of New York and the Mississippi Valley, and 1,600 feet of calcareous shale intervene before a typical Potsdam fauna is reached at the summit of No. 3. This section is typical, as it fixes the horizon of the Georgia fauna below that of the Potsdam, without the shadow of suspicion thrown on it, which there is on the Georgia section, as the latter may be defective through faulting in the shaly argillites above the Olenellus horizon.

§ 59. A section taken in the Highland Range, 125 miles south of the Eureka section, gives a greater variation of sedimentation in the lower portion and less in the upper, and we find that the variation was more favorable to the development and preservation of the fauna, as is shown by the Highland Range section, having an abundant and more varied fauna in the lower 1,500 feet above the quartzite, while in the Eureka section the upper or Potsdam fauna is much larger than in the Highland section.

The section was measured on the west side, half way between Bennett's Spring and Stampede Gap. The base of the section begins at the Quaternary, on the western slope, and the summit forms the highest point of the range.

	Feet.
1. Dark reddish-brown quartzite, evenly bedded, and ripple-marked in some places	350
2. Bluish-gray limestone	35

			Feet.
	Fossils: *Olenellus Gilberti.*		
3.	Buff argillaceous and arenaceous shales, more or less solid near the base and laminated in the upper portions		80
	Fossils: Annelid trails and fragments of Olenellus in the lower part. Higher up, the heads of *Olenellus Gilberti* and *O. Iddingsi* occur in abundance.		
4.	Light-colored gray limestone and bluish-black limestone		16
5.	Sandy, buff-colored shale		40
	Fossils: Annelid trails, *Cruziana* sp.?		
6.	Dark bluish-black limestone		46
7.	Finely laminated buff argillaceous shale		80
	Fossils: *Hyolithes Billingsi* and *Ptychoparia Piochensis.*		
8.	Gray to bluish-black compact limestone		18
9.	Buff arenaceous shales		64
10.	Compact cherty limestone		50
11.	Compact shaly sandstone in massive layers		40
12.	Hard silicious gray limestone, almost quartz at base		12
13.	Yellow to buff sandy shale		70
14.	Bluish-black limestone		16
15.	Yellow to buff, sandy shales		40
16.	Bluish-black, hard, compact limestone		12
	Fragments of fossils.		
17.	Shaly sandstone in massive layers		52
18.	Gray arenaceous limestone		2
19.	(*a*) Buff, sandy shale	40	
	(*b*) Gray arenaceous limestone	30	
	(*c*) Sandy, calcareous shale	3	
			73
20.	(*a*) Massive-bedded, bluish-gray limestone	200	
	Fragments of fossils.		
	(*b*) Compact gray silicious limestone, almost quartzite in some places	400	
	(*c*) Bluish-black, evenly bedded limestone	6	
			606
	Strike N. 30° W., dip 10° E.		
21.	Buff to pinkish argillaceous shale, with fossils, and a few interbedded layers of limestone from 3 to 15 inches thick		125
	Fossils: *Eocystites?? longidactylus, Lingulella Ella, Kutorgina pannula, Hyolithes Billingsi, Ptychoparia Piochensis, Olenoides typicalis, Bathyuriscus Howelli*, and *B. producta.*		
22.	Massive-bedded, silicious limestone; weathering rough and broken into great belts, 200 to 300 feet thick, by bands of color in light-gray, dark-lead to bluish-black; on some of the cliff faces the weathered surface is reddish		1,570
23.	Bluish-black limestone in massive strata, that break up into shaly layers on exposure to the weather. The latter feature is less distinct 850 feet up, and the limestone becomes more silicious, with occasional shaly beds.		1,430
	Fossils: Near the summit specimens were found that are referred to *Ptychoparia minor.*		

Quite a fauna occurs in 23, as found one mile farther south on the line of the section.

Summary of section.

		Feet.
1.	Quartzite	350
2.	Limestone and shales (argillaceous and arenaceous)	1,450
3.	Massive limestones	3,000
	Total	4,800

§ 60. The Eureka Cambrian section gives 750 feet more strata between the quartzite at the base and the base of the Lower Silurian (Ordovician) above; a variation not unexpected, as both the latter and the Devonian strata decrease in thickness between the Eureka and the Southern Nevada sections.

§ 61. The shales above the lower quartzite carry two species in the Highland Range that occur at the same horizon in the Eureka district, viz, *Olenellus Gilberti* and *O. Iddingsi.*

§ 62. The great thickness of strata between the shales carrying Olenellus and division 21 of the section contains more or less remains of trilobites, mostly fragments of the genus *Ptychoparia.*

§ 63. On the east side of the anticlinal arch at Pioche, 20 miles east of the Highland section, the strata resting on the quartzite (2, 3 and 4 of section) contain the following species, four of which are found in the two localities:

Eocystites?? longidactylus.	Hyolithes Billingsi.
Lingulella Ella.	Olenellus Gilberti.
Kutorgina pannula.	Olenoides levis.
Acrothele subsidua.	Crepicephalus Augusta.
Acrotreta gemma.	Crepicephalus Liliana.
Orthis Highlandensis.	

§ 64. The second strongly marked faunal horizon (21 of the section), or the Olenoides fauna, is better shown in the Ely Mountains, just east of the Highland Range, owing to mining operations which have cut into and thrown out large masses of the shales. The same species occur at each locality. The list is given in the section.

§ 65. The fauna of the great limestone belt, above 21, is so obscured by the character of the matrix that only a few specimens were found on the line of the section. One of the species is a small *Ptychoparia* with an occipital spine; and, from the head, it is identified with *Ptychoparia minor* of the Wisconsin Potsdam fauna. Two other species of Ptychoparia occur that are not yet specifically identified. A mile south, on the strike of the strata, an anticlinal, accompanied by a fault, has thrown the limestone down so that a partial section is given; and here a strongly marked Upper Potsdam fauna occurs.

§ 66. The following species are identified:

Bellerophon antiquatus.	Dicellocephalus sp.?
Pleurotomaria, 3 undt. sp.	Ptychoparia (Euloma?) dissimilis.
Hyolithes, 3 n. sp.	Ptychoparia sp.?
Dicellocephalus Pepinensis.	Arethusina Americana.
Dicellocephalus (type of D. Minnesotensis).	Illænurus sp.?

Of this fauna two species are identical with those from the higher Potsdam fauna at Eureka, viz: *Ptychoparia (E.?) dissimilis* and *Arethusina Americana;* and *Bellerophon antiquatus* and *Dicellocephalus Pepinensis* occur in the upper Potsdam sandstone of Wisconsin. The presence of the Pleurotomaria-like shells and the species just mentioned correlates the fauna with that of the upper horizon of the Potsdam faunas of Wisconsin and Nevada.

§ 67. At the south end of the Timpahute Range, in Southern Nevada, Mr. G. K. Gilbert collected *Olenellus Gilberti* and *O. Iddingsi* from fillets of limestone in a yellow argillaceous shale occurring above a massive quartzite, the equivalent of 1 of the Highland Range section.

§ 68. In comparing the Highland Range section with the Eureka section, we find that the stratigraphic and faunal succession, up to the base of the Trenton limestone horizon of the Eureka section, is much alike in each. The Highland Range section was not measured in detail above 23 of the section, but, continuing north along the crest of the range and crossing Stampede Gap, the higher strata, above 23, begin to appear dipping to the southeast, the dip increasing towards the north, and higher beds coming in until at the low pass just north of Bristol the white quartzite just below the Trenton horizon appears. An estimate, made while riding along the eastern base of the range, gave 2,500 feet as the thickness above the highest beds of the section and the quartzite. I think this is less than the actual thickness. Adding 2,500 feet to the 4,800 feet of the measured section, we have 7,300 feet of limestone between the Cambrian and Silurian quartzites, or the Prospect Mountain and Eureka quartzites of the Eureka section.

§ 69. At Pioche, on the Ely Mountains, just east of the line of the section, the lower quartzite (1) gives 1,200 feet. Adding 850 feet to division 1 of the Highland section, we have over 5,500 feet for the Cambrian and 2,500 feet for the Silurian. The hiatus between the two is probably considerable, as at White Pine, 100 miles north, the Lower Silurian (Ordivician) limestone, below the quartzite, is over 5,000 feet thick.

§ 70. On the west side of the Highland Range, west of the highest point, the upper (Eureka) quartzite is shown in a hill north of the road leading from Bennet's Springs to Hiko. Fossils are very abundant. No strata overlying the upper quartzite were observed in the Highland Range between Bennet's Springs and two miles north of Bristol; but in the Pahranagat Range, both Trenton and Silurian (Niagara) fossils occur within 500 feet above the quartzite.

§ 71. West of the Highland Range, at Silver Peak, Nevada (long. 117°, 20′ W., lat. 38° N.), Mr. J. E. Clayton collected a few fossils to which Prof. J. D. Whitney called the attention of the California Academy of Sciences, in 1866, referring to them as probably Upper Silurian or Devonian (Proc. Cal. Acad. Sci., vol. iii, p. 270, 1866).

§ 72. Mr. F. B. Meek subsequently studied the fossils, referring to them as Silurian, and describing *Ethmophyllum Whitneyi* and *E. gracile* (Amer. Jour. Sci., 2d ser., vol. xlv, p. 62, 1868) as corals, and then, in the same year, referring (ibid., vol. xlvi, p. 144) them to the genus Archæocyathus of Billings. No other species were mentioned by Mr. Meek.

§ 73. The original collection from Silver Peak, or a portion of it, was found in the Smithsonian Institution collections, and proved to be-

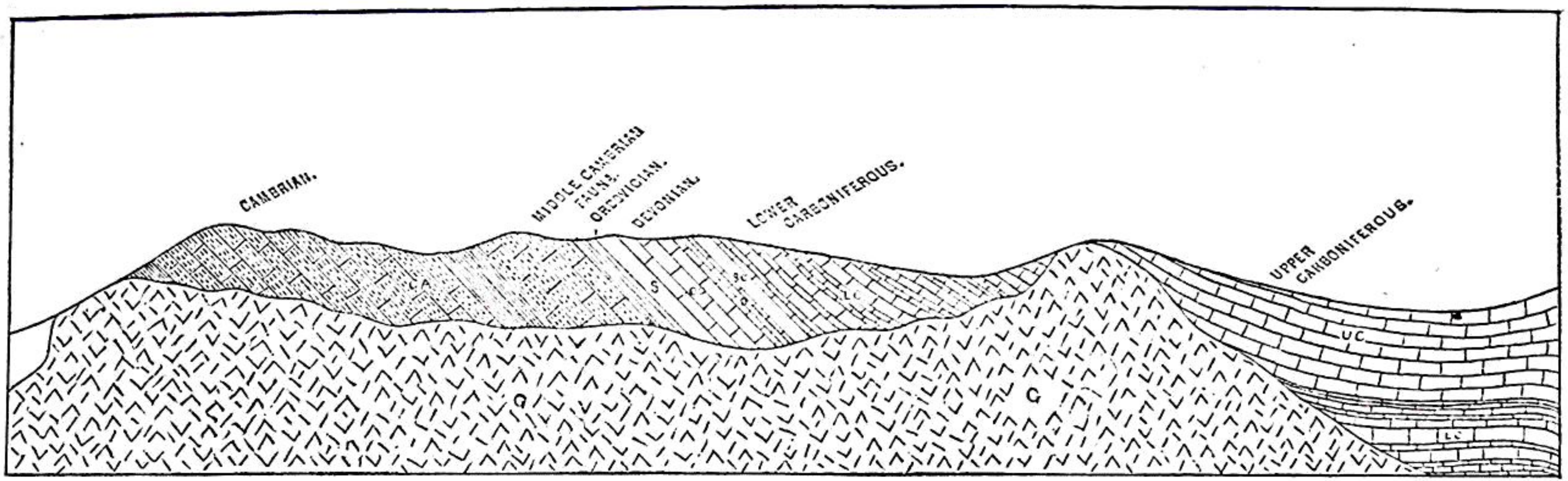


FIG. 4.—Wasatch section. This crosses the Wasatch Mountains a little south of Big Cottonwood Cañon. Copied from map of sections accompanying vol. i, Geol. Expl. Fortieth Parallel. Scale, about 10,000 feet to the inch.

The Cambrian strata are represented as resting unconformably on the granite and as overlaid by the conformable Lower Silurian (Ordovician) strata. The position of the Middle Cambrian fauna is indicated just below the Silurian horizon. CA, Cambrian; S, Silurian; OD, Devonian; LC, Lower Carboniferous; UC, Upper Carboniferous; G, Granite.

Further study in the field will probably result in a somewhat different representation of this section, as it was originally based on rapid reconnaissance work by the geologists of the Fortieth Parallel Survey. The relations between the granite and the overlying strata are not as understood by myself, but are given as in the original section.

long to the Middle Cambrian fauna which is so extensively developed in Central Nevada. We have no description of the section, but the fossils are from a limestone and silico-argillaceous shale, and identical with species found elsewhere. The most noteworthy occurrence is that of *Archæocyathus Atlanticus* and a large brachiopod like *Kutorgina cingulata*, both of which occur over 3,000 miles to the east-northeast on the Labrador coast. The abundant and peculiar type of sponge *Ethmophyllum profundum*, of the L'Anse au Loup locality, is represented by the nearly identical species *E. Whitneyi* at Silver Peak, and the trilobite *Olenellus Gilberti* is scarcely distinguishable from *O. Thompsoni* as it occurs at L'Anse au Loup.

The species now known from Silver Peak are:

Archæocyathus Atlanticus.	Kutorgina (like K. cingulata).
Archæocyathus undt. sp.	Hyolithes princeps.
Ethmophyllum Whitneyi.	Olenellus Gilberti.
Strephochetus ? sp. ?.	

UTAH.

§ 74. The writer visited Big Cottonwood Cañon, in the Wasatch Mountains, during the summer of 1885, and examined the great Cambrian section described by the geologists of the Fortieth Parallel Survey (Geol. Expl. Fortieth Par., vol. i, p. 229; vol. ii, p. 366) more in detail than they had the opportunity of doing. The section was measured from the base near the mouth of Big Cottonwood Cañon, up the cañon to its summit about one mile below Argenta. Owing to the irregularity of the line of outcrop, the thickness of some of the different divisions of the sections was obtained by careful measurement and that of the others by estimates based on partial measurements.

Wasatch or Big Cottonwood section.

	Feet.
1. Black arenaceous shale (Mud markings and cracks, and ripple marks.)	900
2. Massive-bedded, light-gray quartzite	1,000
3. Purplish, thin-bedded sandstone, with bands of greenish-yellow, argillaceous shale near the summit	700
4. Light-gray quartzite and quartzitic sandstone in layers varying from 10 feet down to 2 inches, the thin layers occurring as partings between the more massive bands of layers. In some places the quartzitic sandstone shows grains, and in others they are lost. Stains of purple, iron-rust, reddish-brown, and buff color occur, with bands of purplish arenaceous shale near the base	700
5. Hard, black, arenaceous shale, with specks of mica on the surfaces. Quartzite and shale intercalated near the base	1,000
6. Light-gray quartzite and quartzitic sandstone in layers varying from 10 feet down to 2 inches, the thin layers occurring as partings between the more massive bands of layers. In some places the quartzitic sandstone shows grains, and in others they are lost. Stains of purple, iron-rust, reddish-brown, and buff color occur	200

		Feet.
7.	Arenaceous and argillaceous slates, black, bluish-black, drab, and yellowish-green. This exposure is extensive, the opportunity for finding fossils excellent, and the slates afford a beautiful matrix for their preservation, but none were observed	700
8.	Light-gray quartzite and quartzitic sandstone in layers varying from 10 feet to 2 inches, the thin layers occurring as partings between the more massive bands of layers. In some places the quartzitic sandstone shows grains, and in others they are lost. Stains of purple, iron-rust, reddish-brown, and buff color occur	2,700
9.	Black, sandy, arenaceous, slightly micaceous shales	75
10.	Gray, compact, quartzitic sandstone	700
11.	Purplish and reddish-brown quartzitic sandstone	75
12.	Gray, compact, quartzitic sandstone	3,000
13.	Hard, silico-argillaceous shales, a little sandy in places. Fossils: *Cruziana* sp. ?, *Lingulella Ella*, *Kutorgina pannula*, *Hyolithes Billingsi*, *Leperditia Argenta*, *Olenellus Gilberti*, *Ptychoparia quadrans*, and *Bathyuriscus producta*.	250
	Total	12,000

§ 75. A band of mixed sandy and calcareous rocks rests conformably on 13 of the section, and carries a fauna which refers it to the Lower Silurian (Ordovician).

§ 76. The faunal horizon of the fauna contained in the shales of 13 is at once located by a comparison with the faunas of the Highland Range section. Five out of the eight species are identical, and their stratigraphic position in relation to the great underlying quartzite is the same in both sections; Olenellus comes first, and then *Lingulella Ella*, *Bathyuriscus producta*, &c.

§ 77. The 250 feet of sediment of 13 of the section represent the entire 1,000 feet of Cambrian strata above the quartzite of the Highland Range section that I have included in the Georgia horizon; and the 2,000 to 3,000 feet of the Upper Cambrian of the Eureka and Highland Range sections have no equivalent in the Cambrian section of the Wasatch Mountains. The same condition appears in the Oquirrh Range, next west of the Wasatch, and, from the conformity of the overlying Silurian strata, it appears that during the later Cambrian times there was an area of non-deposition, and as far as known a period of slight or total non-erosion of the Cambrian. The latter statement is largely qualified by the small amount of detailed information we have on the line of contact between the Cambrian and Silurian. That there is a great unconformity, by absence of strata, there is no doubt. One of the most important results of the study of the shales of 13 of the section is the locating of a horizon by which we can compare the section. At Eureka, Highland Range, and Timpahute Range, Nevada, the quartzite of 12 terminated the section below, but now we have 11,750 feet of strata in a conformable series that extend down to the granite (probably Archean).

§ 78. The section in the Oquirrh Range, above Ophir City, shows a quartzite with shales above it carrying *Lingulella Ella*, *Olenellus Gilberti*, and *Bathyuriscus producta*, and at Antelope Spring, in the House Range, Western Utah, Mr. G. K. Gilbert measured the following section (Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iii, p. 167), from the top downward:

	Feet.
1. Gray, massive limestone	200
2. Blue-gray, calcareous shale	200
Fossils (as corrected by C. D. W.): *Acrothele subsidua*, *Agnostus interstrictus*, *Olenoides Nevadensis*, *Ptychoparia Kingi*, *P. Housensis*, and *Asaphiscus Wheeleri*.	
3. Gray limestone, light and dark, chiefly massive	900
4. Vitreous sandstone, umber-brown on weathered face; base not seen	1,000
Total	2,300

§ 79. No. 4 of this section may be correlated with No. 1 of the Eureka and Highland sections or No. 12 of the Wasatch section; and the fossil-bearing shale No. 2 is the stratigraphic, lithologic, and paleontologic equivalent of No. 13 of the Highland Range section; and although there is but one species in common, *Acrothele subsidua*, the general facies of the fauna is comparable to that of the fauna of division 13 of the Highland Range section.

CORRELATION OF SECTIONS.

§ 80. The foregoing sections show that the Middle Cambrian fauna has a distinct stratigraphic position in the Cambrian System and that it is widely distributed over the North American continent. When studying the faunas we found that of the Vermont section to be similar to that of the Bic Harbor and L'Anse au Loup first determined by Mr. Billings; and that the Bic Harbor and the Troy fauna were united by twelve species common to each locality, first determined by Mr. S. W. Ford and Mr. Billings. With the Nevada area there is a greater difference; but the presence of a pre-Potsdam fauna, characterized by the genera *Olenellus*, *Olenoides*, and *Protypus*—all of which are found in the typical Georgia section—serves to unite them.

§ 81. Throughout the Mississippi Valley, including the areas of Upper Cambrian in Llano County, Texas, and in Wisconsin, nothing is known of the Georgia fauna; but to the northwest, on the eastern slope of the Rocky Mountains, Dr. George M. Dawson discovered a species of Olenellus like *O. Gilberti*, also *Protypus senectus*, thus showing the extension of the fauna north from Southern to Central Nevada, and northeast to Kicking Horse Lake in British Columbia.

§ 82. In the accompanying table an attempt is made to correlate the principal sections herein mentioned. The Georgia or Olenellus fauna of the Middle Cambrian and the Potsdam or Dicellocephalus fauna of the Upper Cambrian are taken as the two horizons to locate the local sections on the line of the great section, as their relations are known in the unbroken stratigraphic sections of the Eureka District and the Highland Range.

§ 83. The first section, that of Big Cottonwood Cañon in the Wasatch Mountains, is represented as resting on pre-Cambrian rocks, and extending up to the Middle Cambrian horizon. The Lower Silurian (Ordovician) strata rest directly on the top of this section in nature; but we leave the hiatus between the Middle and Upper Cambrian horizons to show the unconformity, by non-deposition, in this section, as compared with the Eureka section, where the hiatus of the Big Cottonwood section is filled in by several thousand feet of limestone strata containing the fauna that, to a great extent, bridges over the break in the fauna between the top of the Big Cottonwood Cambrian and the Silurian strata.

§ 84. The Eureka section (2) is correlated at its base with section (1) by the stratigraphy and contained fauna. A dark massive quartzite, overlaid by shales, occurs in each; and this horizon is traced across the intervening country between the two sections by its occurrence in the Oquirrh, Tintic, and House Ranges, and also south of Eureka in the Highland Range. It is only in the Wasatch section that the great quartzitic series is traced down towards its base, the uplifts of Nevada not having brought it up, except, possibly, at one point—White's Peak, in the Schell Creek Range of Eastern Nevada—where Mr. G. K. Gilbert measured a section 11,580 feet thick, that is very much like that of the Wasatch. Unfortunately no fossils were found (Geog. and Geol. Expl. and Surv., West 100th Merid., vol. iii, pp. 167, 171). The Eureka section extends up from the Olenellus horizon 6,200 feet to where the upper limit of the Cambrian is drawn. In the table it is represented on the same scale in its extension up to the Trenton horizon of the Lower Silurian (Ordovician).

§ 85. The Highland Range section is essentially a reduplication of the Eureka section, and, like it, joins on the Wasatch section in the same manner at the base. It is not represented in the table.

§ 86. The Grand Cañon Cambrian and pre-Cambrian strata (see fig. 5) have been roughly described by the writer (Amer. Jour. Sci., vol. xxvi, p. 438, 1883). At the top it consists of 1,000 feet of strata carrying a strong and characteristic Upper Cambrian or Potsdam fauna. Then a great unconformity occurs by the erosion of an entire cross-section of the 13,000 feet of strata below that rest unconformably on the underlying highly inclined strata, which, where the section terminated, belong to a system of strata between the Grand Cañon Series and the Archean. In the table the period of erosion is represented as having removed all the strata between the Upper Cambrian and the Lower Cambrian horizon, but I now think it would have been better to classify all the pre-Tonto strata as pre-Cambrian.

§ 87. This to a certain extent is hypothetical, but we know from the

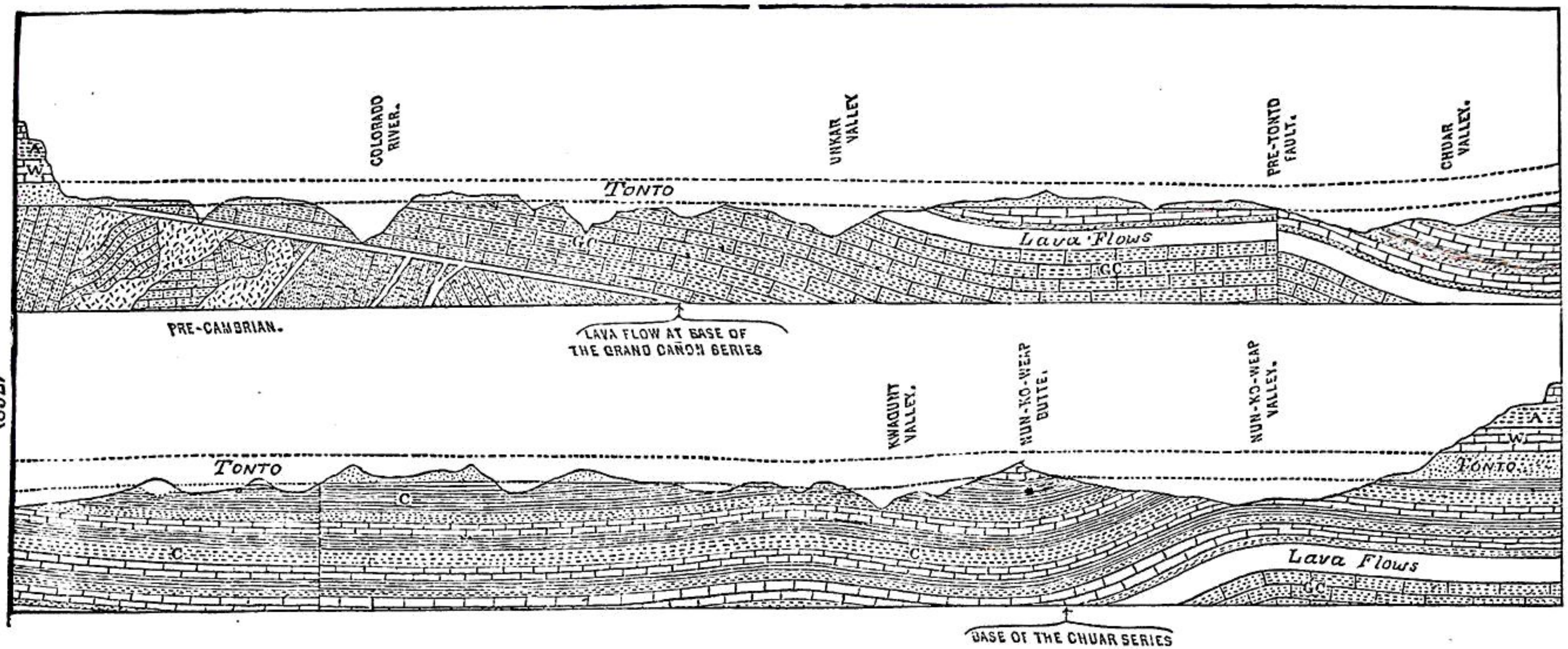


FIG 5.—Grand Cañon section. The section represented by this figure crosses the pre-Tonto strata nearly at right angles to their strike as exposed in the Grand Cañon of the Colorado, Arizona, and studied by the writer. Horizontal scale, 12,500 feet to the inch. Vertical scale about 8,500 feet to the inch.

The Upper Cambrian (Tonto formation) has been removed by erosion on the direct line of the section, but is present, as indicated by the dotted lines around the margins of all the cañons that cut it on the line of the section.

GC, Grand Cañon formation (the lava flows also belong to this); T, Tonto formation; W, Red Wall Carboniferous limestone; A, Aubry Carboniferous sandstone (above this comes the Aubry Carboniferous limestone, which forms the outer wall of the cañon). All the strata beneath the Tonto Formation are considered as pre-Cambrian.

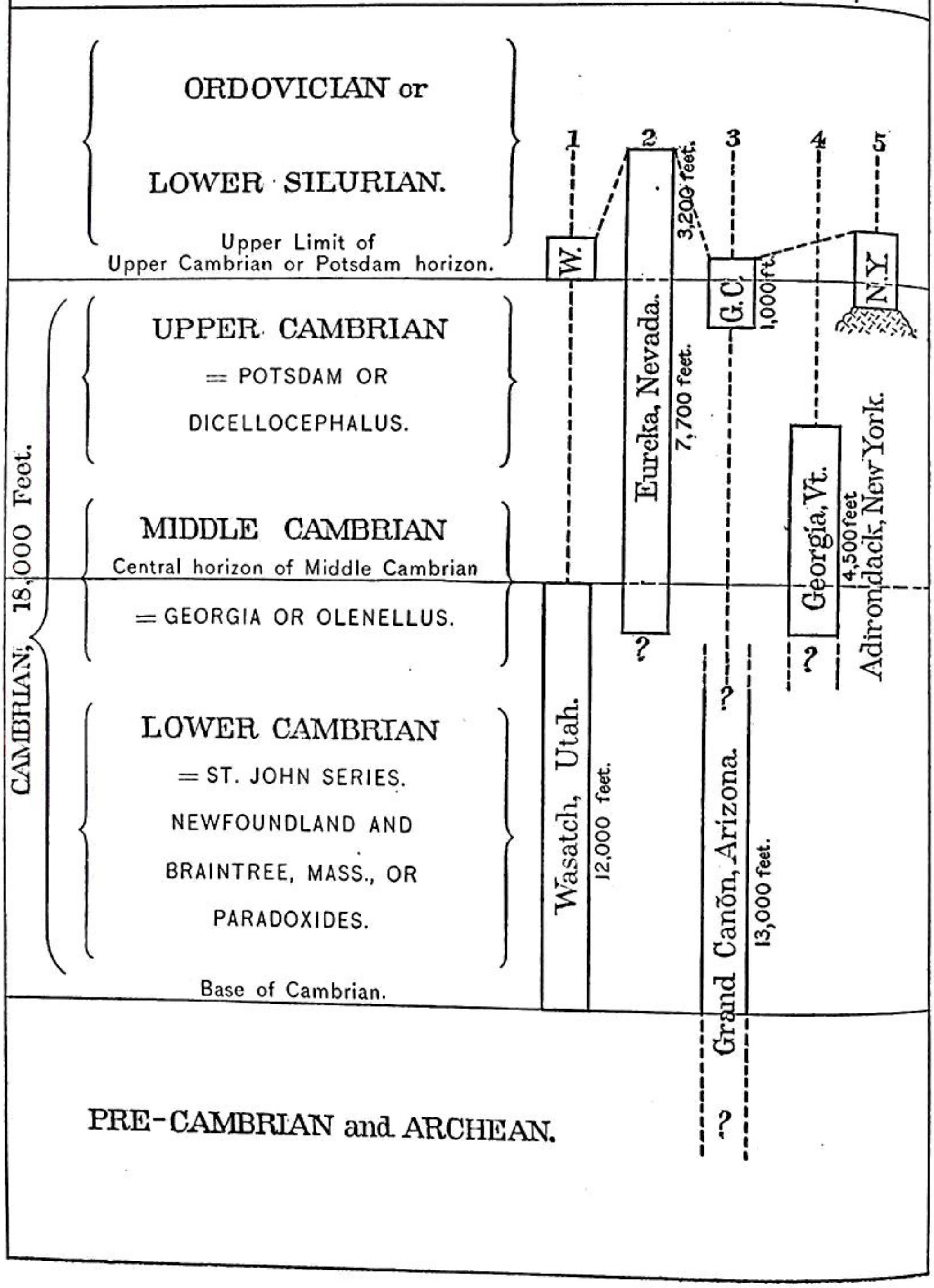
physical conditions of the unconformity that a great period of erosion existed whose duration might readily have permitted of the deposition of the great series of strata that occur below the Upper Cambrian, over the area of Utah and Nevada. I now think that in the Grand Cañon section the Middle Cambrian and the Lower Cambrian were periods of erosion, and not represented in the section, and that the 4,000 or 5,000 feet of limestone of the Eureka and Highland sections and the detrital sediments of the Wasatch section are the deposits accumulated in the sea of the Great Basin area when the area of the Grand Cañon was a land surface. The latter was of considerable extent, as essentially the same section as that of the Grand Cañon of the Colorado occurs in Llano County, Central Texas, and in Minnesota and Wisconsin.

§ 88. The strata of the older series of the Grand Cañon section are in a remarkable condition of preservation, considering their geologic age. In the Chuar formation, or the upper 6,000 feet, limestones and argillaceous shales alternate, that lithologically resemble the Trenton limestone and Utica shales of the New York section. The party-colored shales of the lower 700 feet recall the friable clays of the Permian. In fact, there is no evidence of the great age of these strata in their physical aspect, as they might be taken quite as readily for the friable and unchanged strata of the Trias and Cretaceous series of Southern Utah. The lower 6,000 feet are sandstone, with interbedded lava flows toward the upper portion. Ripple marks and mud cracks abound in many of the layers, but not a trace of a fossil or the trail of a mollusk or annelid was seen.

§ 89. Midway of the lower portion of the shales and limestones of the overlying Chuar strata the presence of a fauna is shown by a minute Discinoid or Patelloid shell, a small Lingula-like shell, a species of Hyolithes, and a fragment of what appears to have been the pleural lobe of the segment of a trilobite belonging to a genus allied to the genera Olenellus, Olenoides, or Paradoxides. There is also an obscure Stromatopora-like form that may or may not be organic. The fauna, as given above, is very unsatisfactory, but it shows the presence of a fauna that is Cambrian in character, as far as we know, although it may be a trace of a fauna preceding that of the Lower Cambrian of the Atlantic border; and as the stratigraphic evidence favors this view I do not think we can consider it of Cambrian age.

§ 90. The fourth section of the table is that of Georgia, Vt. While the Potsdam horizon is probably present, it is not certainly known in the section. The section is represented on the same proportional scale as Nos. 1, 2, and 3, although we fully appreciate the fact that a much thinner series of strata in one locality may represent the same relative period of deposition in another area where the accumulation of sediment was very much greater. When we attempt in the future to corre-

Table showing the correlations of typical Cambrian Sections with reference to the Potsdam and Georgia faunas of the Cambrian.



late the various sections and faunas of the entire Cambrian System of North America, all the sections will be drawn on a plan, so that the divisions of each section will show their relations to each other as far as practicable. The Vermont section is placed on the Middle Cambrian line by the evidence given by its contained fauna.

§ 91. Section 5 shows the Upper Cambrian horizon and the Lower Silurian section up to the top of the Trenton limestone as developed in New York State. The Middle Cambrian is unknown to me in New York except east of the Hudson River, although it may occur in the southeastern portions of the State. The Troy and other sections of the Middle Cambrian on a line south of the Georgia section are included under section 4 of the table; also, that of the Straits of Belle Isle.

§ 92. The object of the table being to show the stratigraphic relations of the three divisions of the Cambrian fauna, many details are omitted that may be expected when a review of the Upper Cambrian or Potsdam fauna is completed.

TABLE OF THE MIDDLE CAMBRIAN FAUNA.

§ 93. In the following table the extent and character of the fauna are shown and also its geographic distribution.

Under the head of Highland Range we include the fauna at Pioche, in the Ely Range, and the species from the Timpahute Range and Silver Peak, Nevada, as they are all from the same geologic horizon and geographic area.

Table of distribution of Middle Cambrian fauna.

	Georgia, Vt.	Bic Harbor.	Labrador.	Newfoundland.	Troy, N. Y.	Eureka, Nev.	Highland Range.	Wasatch Mountains.	House Range.	Oquirrh Range.
ALGÆ.										
Palæophycus congregatus Billings	×									
incipiens Billings	×		×		×					
Cruziana sp.(?)	×									
SPONGIÆ.										
Archæocyathus Atlanticus Billings			×				S.P. ×			
Billingsi Walcott			×							
sp.?							S.P. ×			
Ethmophyllum profundum Billings			×							
Rensselaericum Ford					×					
rarum Ford					×					
Whitneyi Meek							S.P ×			
Leptomitus Zitteli Walcott	×									
Protospongia fenestrata Salter						×				
Strephochetus? sp.?						×	S.P. ×			

Table of distribution of Middle Cambrian fauna — Continued.

	Georgia, Vt.	Bic Harbor.	Labrador.	Newfoundland.	Troy, N. Y.	Eureka, Nev.	Highland Range.	Wasatch Mountains.	House Range.	*Oquirrh Range.*
HYDROZOA.										
Diplograptus ? simplex Emmons	×									
Climacograptus ?? Emmonsi Walcott	×									
CRINOIDEA.										
Eocystites ?? longidactylus Walcott							×			
? sp. ?	×									
ANNELIDA.										
Arenicolites sp. ?	×					×				
BRACHIOPODA.										
Lingulella cælata Hall (sp.)		×			×					
Ella H. & W.							×			
Kutorgina cingulata Billings	×		×				S.P. ?			
Labradorica Billings	×		×							
pannula White (sp.)							×			
Prospectensis Walcott						×				
Iphidea bella Billings		×	×	×						
Acrotreta gemma Billings							×			
Acrothele subsidua White							×		×	
Obolella chromatica Billings			×							
Circe Billings		×								
crassa Hall (sp.)		×			×					
gemma Billings		×			×					
nitida Ford					×					
Orthis Highlandensis Walcott							×			
Orthisina festinata Billings	×									
orientalis Whitfield	×									
? transversa Walcott	×									
? (sp. undetermined)	×									
2 sp. ?		×	×							
sp. ?					×					
Camarella ? antiquata Billings	×									
? sp. ?		×	×							
LAMELLIBRANCHIATA.										
Fordilla Troyensis Barrande					×					
GASTEROPODA.										
Stenotheca ? elongata Walcott						×				
rugosa Hall (sp.)		×	×	×	×					
Scenella conula Walcott						×				
reticulata Billings				×						
retusa Ford		×			×					
? varians Walcott	×									
Platyceras primævum Billings		×			×					

Table of distribution of Middle Cambrian fauna—Continued.

	Georgia, Vt.	Bic Harbor.	Labrador.	Newfoundland.	Troy, N. Y.	Eureka, Nev.	Highland Range.	Wasatch Mountains.	House Range.	Oquirrh Range.
PTEROPODA.										
Hyolithes Americanus Billings		×			×					
Billingsi Walcott	×?		×							
communis Billings		×			×					
var. Emmonsi Ford					×					
impar Ford					×					
princeps Billings		×					S.P. ×			
sp. (undetermined)					×					
Hyolithellus micans Billings		×			×					
Salterella pulchella Billings	×		×							
rugosa Billings			×							
CRUSTACEA.										
Leperditia Argenta Walcott								×		
Troyensis Ford					×					
Protocaris Marshi Walcott	×									
PŒCILOPODA.										
Agnostus interstrictus White									×	
nobilis Ford					×					
sp.?		×								
Microdiscus lobatus Hall (sp.)		×			×					
Meeki Ford					×					
Parkeri Walcott	×									
speciosus Ford		×			×					
Mesonacis Vermontana Hall (sp.)	×									
Olenellus asaphoides Emmons, sp					×					
Gilberti Meek						×	×	×		×
Iddingsi Walcott						×	×			
Thompsoni Hall	×	×	×							
Olenoides flagricaudus White (sp.)							×			
levis Walcott			×				×			
? Marcoui Whitfield (sp.)	×									
Nevadensis Meek (sp.)									×	
quadriceps Hall & Whitfield (sp.)						×		×		
spinosus Walcott						×				
typicalis Walcott							×			
Wahsatchensis Hall & Whitfield							×	×		
Bathynotus holopyga Hall	×									
Ptychoparia Adamsi Billings	×	×								
Housensis Walcott									×	
Kingi Meek (sp.)									×	
miser Billings (sp.)			×							
Piochensis Walcott							×			
? Prospectensis Walcott						×				
quadrans Hall & Whitfield (sp.)								×		
subcoronata Hall & Whitfield (sp.)								×		
(A) strenuus Billings		×								

Table of distribution of Middle Cambrian fauna — Continued.

	Georgia, Vt.	Bic Harbor.	Labrador.	Newfoundland.	Troy, N. Y.	Eureka, Nev.	Highland Range.	Wasatch Mountains.	House Range.	Oquirrh Range.
PŒCILOPODA—Continued.										
Ptychoparia Teucer Billings (sp.)	....	×	....	....	....	....	....	....	....	....
trilineata Emmons (sp.)	....	×	....	....	×	....	....	....	....	....
Vulcanus Billings (sp.)	....	×	....	....	....	....	....	....	....	....
2 sp.?	....	×	....	....	....	×	....	....	....	....
Crepicephalus Augusta Walcott	....	....	....	....	....	....	×	....	....	....
Liliana Walcott	....	....	....	....	....	....	×	....	....	....
Oryctocephalus primus Walcott	....	....	....	....	....	....	×	....	....	....
Anomocare parvum Walcott	....	....	....	....	....	×	....	....	....	....
Protypus Hitchcocki Whitfield (sp.)	×	....	....	....	....	....	....	....	....	....
senectus Billings (sp.)	×	×	×	×	....	....	....	....	....	....
var. parvulus Billings	×	×	×	....	....	....	....	....	....	....
Solenopleura Nana Ford	....	....	....	....	×	....	....	....	....	....
Bathyuriscus Howelli Walcott	....	....	....	....	....	....	×	....	....	....
productus H. & W. (sp.)	....	....	....	....	....	....	×	×	....	×
Asaphiscus Wheeleri Meek	....	....	....	....	....	....	....	....	×	....

SUMMARY OF FAUNA.

§ 94. The total fauna, as known to me, includes 43 genera, 107 species, and 2 varieties:

	Genera.	Species.
Algæ	2	3
Spongiæ	5	10
Hydrozoa	2	2
Crinoidea	1	2
Annelida	1	1
Brachiopoda	9	24
Lamellibranchiata	1	1
Gasteropoda	3	7
Pteropoda (1 variety)	3	9
Crustacea	2	3
Pœcilopoda (1 variety)	14	45
Total	43	107

§ 95. Of the above, 14 species are not described in the text. Five of these are from Canada and have not yet been named or described, viz: 2 species, Orthis; 1 species, Ptychoparia; 1 species, Camarella; and 1 species, Agnostus. The 3 species of Plantæ are left to be studied with the Upper Cambrian fauna. A fragment of a species of Orthisina or Orthis occurs at Troy, New York, and also one at Parker's quarry, Vermont, that indicate species different from those described. The undescribed species of Hyolithes is from Troy and will probably be described by Mr. Ford. The species of Ptychoparia, from Nevada, is known only by imperfect fragments, and the Nevada species of Archæocyathus is not represented by sections that give anything of the exterior form or surface. The Eocystites, from Vermont, is represented only by a few detached plates.

STRATIGRAPHIC POSITION OF THE FAUNA.

§ 96. The relations of the Georgia and the Potsdam faunas have been noticed in speaking of the Nevada sections, where they are shown to be stratigraphically separated by 3,000 feet or more of limestone. But three species, *Protospongia fenestrata*, *Stenotheca elongata*, and *Acrotreta gemma*, are known to pass up to the Upper Cambrian or Potsdam horizon. In the Georgia section, Vermont, one of the species, *Ptychoparia Adamsi*, appears to pass up into the horizon of the "lentile" (9) of the section, where the fauna is more like that of the Potsdam; and, of the other species, *Orthisina orientalis* is much like *O. Pepina* of the Potsdam sandstone of Wisconsin; but the fauna as a whole is so clearly distinct from the typical Potsdam of New York, Wisconsin, Tennessee, Alabama, Texas, Arizona, Nevada, and Montana, that, even without any section to show their relations to each other, I would not think of correlating them as possible faunas of the same geologic horizon.

§ 97. The stratigraphic relations of the fauna of the Paradoxides horizon of St. John, Braintree, and Newfoundland are not so clearly proven as those of the Upper Cambrian fauna. The only locality known where the two faunas are in the same geographic area is about Conception Bay, Newfoundland. At Topsail Head about 160 feet of limestone is exposed, overlaid by a dark shale. All stratigraphic connection with other sections in the vicinity is broken. The fossils in the limestone are not numerous, but Mr. Billings pronounced them Potsdam (Geol. Newfoundland, p. 157; reprint of report for 1868), and identified Salterella and *Crania* (*Kutorgina*) *Labradorica*, and I found in the collections of the Geological Survey of Canada *Scenella reticulata*, *Stenotheca rugosa*, *Iphidea bella*, and *Protypus senectus* var. *parvulus*, which gives six species that are also known from the Middle Cambrian horizon of L'Anse au Loup.[1] Special stress is placed by the writer on the occurrence of these fossils at Topsail Head, as it is in the midst of the Paradoxides basin. Mr. Alexander Murray correlated the Topsail Head limestone with that of other localities, and places it beneath the Paradoxides-bearing shales of St. Mary's Bay (on the page cited above), but without paleontologic or stratigraphic evidence that authorized him to say more than that a supposed connection is indicated.

[1] Mr. Billings called all the Middle Cambrian fauna Lower Potsdam, which explains his referring the Topsail Head fossils to the Potsdam.

§ 98. Not having stratigraphic evidence of the relation of the Georgia or Middle Cambrian fauna and the Paradoxides or Lower Cambrian fauna, other than that they occur in the same area and are not in the same stratum of rock, we turn to the fauna to aid in the settlement of the question.

Of the 32 genera of the American Paradoxides horizon, 15 pass up into the Olenellus horizon, viz: Arenicolites, Protospongia, Archæocyathus?, Eocystites??, Lingulella, Acrotreta, Acrothele, Kutorgina, Orthis, Stenotheca, Hyolithes, Agnostus, Microdiscus, Solenopleura, and Ptychoparia. Of these, Arenicolites, Protospongia, Lingulella, Kutorgina, Acrotreta, Orthis, Hyolithes, Stenotheca, Agnostus, Microdiscus?, and Ptychoparia continue on up into the Potsdam or Upper Cambrian horizon, leaving but four genera that are common to the Middle and Lower Cambrian horizons. One genus, Dendrograptus, is doubtfully identified in the Paradoxides horizon of New Brunswick, and occurs in the Upper Cambrian, but is, as yet, unknown in the Middle Cambrian. The genus Agraulos is also found in the Lower and Upper, but not in the Middle Cambrian. Of species, not one of the 64 of the American Lower Cambrian fauna are known to occur in the Middle Cambrian fauna, which, with its 107 species, stands out clearly from the older fauna and also from the more recent Potsdam fauna, as but 3 of its species, *Protospongia fenestrata*, *Stenotheca elongata*, and *Acrotreta gemma*, are known to be common to them; and 16 of the genera in the Middle Cambrian are not known to pass up into the Potsdam or into the Lower Silurian (Ordovician) fauna. Not one species is known to be common to the Lower and Upper Cambrian horizons.

GENERAL PALEONTOLOGIC CHARACTERS OF THE FAUNA.

PLANTÆ.

§ 99. Owing to the obscure character of the two species of Palæophycus, it is difficult to say that they were not formed by filling in of worm borings or the trails of some annelid or mollusk. Cruziana I now believe to have been a fucoid, and hope soon to present the reasons for the belief, as a beautiful series of specimens was obtained from the Upper Cambrian strata of the section in the Grand Cañon of the Colorado, Arizona.

SPONGIÆ.

§ 100. The sponges of the Middle Cambrian bid fair to form one of the important elements of the fauna, as they now include 5 genera and 10 species, and the collecting at Silver Peak, one of the most prolific localities in Nevada, has been of a superficial character. *Ethmophyllum profundum* grows to a large size and is, as described by Prof. Alpheus Hyatt, the reef builder of its time. (Science, vol. vi, p. 386, 1885.) *Archæocyathus Atlanticus*, another prolific form, has a wide geographic range, as we find it both in Labrador and Nevada.

The genus Ethmophyllum is a very interesting form, for in it we observe the septa, vesicular structure, and poriferous system that later, in Paleozoic time, appear in the various divisions of the Zoantharia branch of the Actinozoa (Zaphrentis, Cystiphyllum, Favosites, &c.); to include Archæocyathus and allied genera, Dr. Bornemann has proposed a new class of the Cœlenterata, which he calls Archæocyathinæ.

Leptomitus Zitteli is the only representative we have in the Cambrian showing the base or root of the "anchoring sponges."

Protospongia fenestrata ranges nearly through the Cambrian of Wales, according to Dr. Hicks; and in America the genus, if not the species, is now known from both the Lower Cambrian of New Brunswick and the upper portions of the Middle Cambrian of Nevada, the great vertical range being accompanied by a correspondingly wide geographic distribution. Like most of the other Cambrian sponges there is not enough known of its structure to accurately place it in the classification of the *Hexactinellidæ*. The minute structure of Archæocyathus and Ethmophyllum is not well shown in the Cambrian specimens, owing, in all probability, to the destruction of the spiculæ in the replacement by calcite. In the one silicified species, *Ethmophyllum Minganensis*, from the Lower Silurian, the spiculæ are preserved, and in *Archæocyathus Billingsi* we observe what appear to be spiculæ in the cup and interseptal spaces, but not in the walls or septa.

HYDROZOA.

§ 101. *Diplograptus ? simplex* is a form allied to the leaf-like graptolites of the Lower Silurian (Phyllograptus), but we know too little of the species to even give it a proper generic reference; the same may be said of the species referred to *Climacograptus ? Emmonsi*. All we can say of them is that they represent the graptolidæ at the horizon of the Middle Cambrian. Matthew recognizes two genera of graptolites in the St. John Group, Dendrograptus and Protograptus; the former being found in the Upper Cambrian (Potsdam) horizon shows that the type ranges through the Cambrian System.

ECHINODERMATA.

§ 102. A glance at the figures illustrating *Eocystites?? longidactylus* shows that we have not yet reached a simple type of the Cystoidea in this Cambrian fauna, although, in the irregular size and great number of the plates, the pore-like openings at their margins, and the long simple arms, a general looseness of organization is indicated that is wanting in the compact, regular forms of the superior fauna.

The genus was founded on single plates from the St. John Group; and somewhat similar plates occur in the Wisconsin Potsdam sandstone. Until entire or nearly entire specimens are found from these horizons, we cannot compare the *E.?? longidactylus* with what these plates represent.

BRACHIOPODA.

§ 103. Nine genera and 24 species from the Middle Cambrian, and 6 genera, with 12 species (Matthew), from the Lower Cambrian of America, show a total of 10 genera and 36 species for this class, from below the Upper Cambrian (Potsdam of America, Olenus Zone of Europe).

§ 104. The family Lingulidæ is represented by 1 genus and 2 species, each of which presents the high fissured area of the genus Lingulella and also its delicately sculptured surface; and *L. Ella* affords a glimpse of the muscular scars of the interior of the dorsal (?) valve that places the genus near the genera Obolella and Lingula.

§ 105. The Obolidæ has the largest development of the Middle Cambrian families of the Brachiopoda, and includes 5 genera and 12 species, viz: Kutorgina, 4 species; Iphidea, 1 species; Acrotreta, 1 species; Acrothele, 1 species; Obolella, 5 species. The genera Obolella and Kutorgina represent the Obolidæ proper, and the 3 remaining genera the Siphonotretidæ, if we may use the latter as a subfamily. Obolella first appears as *O. maculata* Hicks in the Paradoxides horizon (Lower Cambrian) of Wales, and reaches its greatest development in the Middle Cambrian horizon of America, from which 5 well-defined species have been recognized. From the Upper Cambrian we at present know of but 2 species that will be retained in the genus. The characters of the genus are well shown by the figures on plates ix and x. The genera Acrotreta, Iphidea, and Acrothele belong to a natural group having a conical ventral valve perforate at the apex, with more or less of a false area and a depressed dorsal valve. Acrothele is considered by its author as most nearly related to the genera Obolella and Acrotreta, but, from the information we now have, I would place it nearer to the latter and still nearer to the genus Schizambon (Monographs United States Geological Survey, vol. viii, p. 69).

The genus Kutorgina has a wide geographic distribution and a vertical range from the Lower Cambrian of Sweden and New Brunswick up through the Middle Cambrian, where it reaches its greatest development as now known, into the Upper Cambrian of Nevada and Montana, on the western side of the American continent. It is not certain that the genus may not be divided, as the type *K. cingulata* is a large calcareous shell and the other species are smaller and horny or corneo-calcareous. We find traces of the muscular scars on the interior of the valves of the *K. cingulata*, but not of the other species.

§ 106. The Strophomenidæ has 2 genera and 8 species, 4 of which are not yet described. The generic reference to Orthisina is doubtful in most instances, as the condition of the specimens is too imperfect to give the characters of the interior of the valves. *O. festinata* appears to be a true Orthisina, and the others are considered as provisionally referred to the genus. The 1 species referred to Orthis is apparently not an Orthisina, but, at the same time, its surface characters and the interior of the ventral valve tend to remove it from the typical forms of the genus Orthis.

§ 107. The Rhynchonellidæ appears thus far to be restricted to the genus Camarella, which makes its first appearance in the Middle Cambrian of Labrador and Vermont. The Vermont species is somewhat doubtfully referred to the genus, and the Labrador species is yet undescribed. It is very much like *Triplesia primordialis* of the Upper Cambrian (Potsdam) horizon of Wisconsin and Texas.

LAMELLIBRANCHIATA.

§ 108. M. Barrande suggests that the little shell *Fordilla Troyensis* may be the valves of a crustacean, but, at the same time, calls attention to its resemblance to shells of the genus Nucula; and Mr. Ford noticed the resemblance of the single valves to a small Modiolopsis. I think that it is a lamellibranchiate shell, but there is an element of uncertainty owning to the obscure character of the muscular impressions. If a true lamellibranch it is the earliest now known, and the record of the class is not taken up again until the passage beds between the Cambrian and Lower Silurian (Ordovician) are met with. It cannot be that *Euchasma Blumenbachi* Billings of the Calciferous formation (Geol. Can., Pal. Foss., vol. i, p. 361, fig. 348) is the first of its class, judging from its size and its relation to the genus Conocardium. *Eopteria typica*, *E. Richardsoni*, and *E.? ornata* Billings (Ibid., pp. 221, 306, 307) complete the list of the Calciferous species, and, like *E. Blumenbachi*, are far in advance of what one would anticipate of the first of the family to which they are referred (Aviculidæ).

GASTEROPODA.

§ 109. The type represented by *Stenotheca rugosa* ranges throughout the Cambrian, and is found on both sides of the Atlantic basin in the Lower Cambrian and from Labrador to New York in the Middle Cambrian. Its representative in the Wisconsin Potsdam sandstone has not yet been described. Both the genera Stenotheca and Scenella are Patella-like shells, with unbroken margin and surface and with the apex turned forward, as far as we now know from the Middle Cambrian species.

Mr. G. F. Matthew considers *Stenotheca Acadica* as nearer the genus Parmophorus of the Fissurellidæ than to the Patellidæ (Canadian Rec. Sci., vol. ii, p. 10, 1886).

The minute shell referred to *Platyceras primævum* is, as far as known, the first representative of the genus Capulus, which, increasing in numbers very slowly through the Lower Silurian (Ordovician), reaches a great development in the Devonian, and, diminishing in the Carboniferous, comes down to the present with a few widely-distributed species.

All the gasteropods appear to have been shallow-water forms, although we now find them preserved in compact limestones.

PTEROPODA.

§ 110. Three genera and nine species, with numerous specimens, give this class a prominent position in most localities of the Middle Cambrian strata, although in several instances but few specimens are met with. This is noticeable at Georgia, Vermont, and in the Highland Range of Nevada. Specimens occur abundantly in the silico-argillaceous shales of the Wasatch Cambrian, in the clear limestone of the Ely Mountains of Nevada, in the conglomerate limestones of Troy and Bic Harbor, and in the silicious magnesian limestones ("Red Sandrock") of Vermont.

The extended range of the species *Hyolithes Billingsi* and *H. princeps* from Labrador to Nevada is in accord with the free habits of the young, if not of the older, individuals. The presence of transverse diaphragms in the tubes of *H. communis* and *H. impar* allies the species to the types, in the St. John series, that have been so well described by Matthew under the genera Diplotheca and Camarotheca. A noticeable feature of the presence of the diaphragms is their almost total absence in the species of the Upper Cambrian, Silurian, and Devonian.

The slender tube of Hyolithellus recalls the Dentalidæ; and its operculum, which is one of the prettiest fossils of the Troy Cambrian rocks, might belong to a shell allied to Dentalium and also to Hyolithes.

Although it is stated, under the description of the genus Salterella, that I agree with M. Barrande that the relations of the genus are with Tentaculites and Hyolithes, there is an element of doubt so strong that, until more evidence is brought forward, the genus is left in a doubtful position in relation to its affinities to other genera of the Pteropoda.

CRUSTACEA.

§ 111. The strongly-marked *Leperditia Troyensis* is not unexpected at this horizon, as the genus is present in the Lower Cambrian of Wales. In *L. Argenta* one of the largest species of the genus is found, if the shell referred to Leperditia truly belongs to it and is not one side of the carapace of a phyllopod crustacean allied to Hymenocaris or Protocaris. The latter is possible, but, from a careful study of the specimen, does not appear probable. *Protocaris Marshi* is one of the earliest, if not the earliest, phyllopod crustacean now known, and is closely allied to the Upper Cambrian *Hymenocaris vermicauda*.

PŒCILOPODA.

§ 112. I prefer to use Pœcilopoda, as the class name includes the Trilobita, for reasons given in 1881 (Bull. Mus. Comp. Zoölogy, vol. viii, pp. 208–211). The class is represented by the Trilobita in the Cambrian, with the exception of the limuloid-like Aglaspis of the Wisconsin Potsdam sandstone. The Eurypterida presents its earliest form, as at present known, in *Echinognathus Clevelandi* of the Middle Lower

Silurian (Ordovician) of New York (Amer. Jour. Sci., 3d ser., vol. xxiii, p. 213, 1882).

§ 113. The Trilobita, with 14 genera and 45 species, so far outranks all the other orders that without the latter the stratigraphic position of the Middle Cambrian could be readily determined, although the Spongiæ, Brachiopoda, and Pteropoda present a facies distinct from that of the same classes in the Lower and Upper Cambrian.

§ 114. The Agnostidæ is represented in the Lower Cambrian of America by 2 genera and 10 species: Agnostus, 8 species; Microdiscus, 2 species. In the Middle Cambrian, by Agnostus, 3 species, and Microdiscus, 4 species. Several species of Agnostus occur in the Upper Cambrian, 10 or more; and Microdiscus is represented by the curious *Pemphigaspis bullata* of the Wisconsin Potsdam sandstone (Sixteenth Rep. N. Y. State Cab. Nat. Hist., p. 221, pl. 5A, figs. 3, 4, and 5, 1863).

Agnostus interstrictus belongs to the widely-distributed *A. pisiformis* type, of which *A. Acadicus* is the representative in the St. John series of New Brunswick, and *A. Josepha* in the Wisconsin Potsdam sandstone. *A. nobilis* is not unlike *A. parilis* of the Wisconsin Potsdam sandstone. (Sixteenth Rep. N. Y. State Cab. Nat. Hist., p. 179, pl. x, figs. 24 and 25, 1863).

In Microdiscus there is a slight advance on the typical form of Agnostus with two segments, and I think the genus should be included in the family Agnostidæ. The 4 species of Microdiscus have a somewhat similar appearance, and differ from the Lower Cambrian (St. John) species *M. Dawsoni* and *M. pulchellus* (=*M. punctatus*, U. S. Geol. Survey, Bull. No. 10, p. 24, pl. ii, figs. 1, 1*a–c*), the former having a highly ornamented surface and the latter a strong nuchal spine.

§ 115. The genera of the Olenidæ of the American Middle Cambrian fauna known at present are: Mesonacis, 1 species; Olenellus, 4 species; Olenoides, 8 species; and Bathynotus, 1 species. The genus Mesonacis is the connecting link between Paradoxides of the Lower Cambrian and Olenellus of the Middle Cambrian; in the development of Olenellus, the genetic relation of that genus to Paradoxides is shown more clearly. Mesonacis is confined to one locality, as far as we now know, and its value in stratigraphic geology is thus limited.

The two genera Olenellus and Olenoides have a wide geographic range and occur together in most localities. Olenellus is more limited in vertical range, having been found through about 500 feet of strata, while Olenoides extends up 1,200 feet or more in the Highland Range section of Nevada, and probably, into the Upper Cambrian horizon. The genus Olenellus, wherever found in a well-defined section, is characteristic of a horizon far below that of the typical Upper Cambrian or Potsdam horizon of North America. Its relations to other genera are discussed under the remarks on the remarkable species *O. Gilberti*.

Olenoides, with its 8 species, is nearly as characteristic of the

Middle Cambrian fauna as Olenellus. *O. typicalis* is a strongly-marked type and appears to be one of the forms that carried the Paradoxides type up through the Cambrian to the Dicellocephalus type of the Upper Cambrian. *O. Marcoui* is also allied to Dicellocephalus; and the genus Olenoides, as a whole, is the representative of Dicellocephalus of the Upper Cambrian. *Bathynotus holopyga* is another curious form, restricted, so far as known, to one locality and horizon. Its relations appear to be with Olenoides and Dicellocephalus.

§ 116. The Conocephalidæ family predominates in the trilobitic portion of the fauna in having 6 genera and 21 species.

Ptychoparia Piochensis, with its 19 thoracic segments, adds to the genus Ptychoparia a greater range in the number of segments of the thorax, 14–15 being changed to 14–19. The other species of the genus are essentially of the same general type as the typical forms.

Crepicephalus is hardly of generic value, although so used in this paper. The study of the Upper Cambrian species will assist in the determination of its generic position.

Oryctocephalus adds another genus to the Conocephalidæ, and it appears to be warranted by the combination of characters observed in the head and pygidium. The peculiar glabellar furrows and the strong spinous pygidium are unlike any other known to me.

The genera Anomocare and Solenopleura are not sufficiently well represented to demand special notice.

In Protypus there is a combination of characters recalling Ptychoparia; at the same time, the glabella and head point to Angelina and Bathyurus. The genus has a wide geographic range and is, as far as we know, confined to the Middle Cambrian.

§ 117. There is a group of genera intermediate between the Conocephalidæ and the Asaphidæ that, as yet, have not been arranged in any defined family. They include the genera Bathyurus, Bathyuriscus, and Asaphiscus, and may be defined as the family Bathyuridæ, as follows: Trilobites of an oval form; medium size; capable of rolling up. Head a little longer than the pygidium; glabella distinctly defined, with or without distinct glabellar furrows; facial sutures terminating posteriorly within the genal angles and anteriorly on the frontal margin; eyes medium-size to large, semilunar. Thorax with 7–9 segments; pleuræ furrowed. Pygidium somewhat smaller than the head, formed of numerous (6, 8+) closely united segments; border flattened, smooth. Doublure of head and pygidium thin and well developed. The general assemblage of characters places the Bathyuridæ close to the Asaphidæ, but I do not think we should include its genera under the typical group of the latter.

§ 118. *Asaphiscus Wheeleri* suggests forms placed under the genus Asaphus, but the glabella and the direction of the facial suture in front of the eyes are those of the Conocephalidæ. The species and genus is known from only one locality and horizon. *Bathyuriscus Howelli* and

B. producta appear at the same geologic horizon as *Asaphiscus Wheeleri*, but not at the same localities. In the presence of well-marked glabellar furrows and the general appearance of the entire body, Bathyuriscus is allied to Ogygia. With the fragmentary material of the Upper Cambrian still unstudied, we will not attempt comparisons; but from the resemblance between this group of trilobites and the Asaphidæ of the Lower Silurian (Ordovician) there is probably a group of genera and species corresponding to them in the Upper Cambrian or Potsdam horizon.

§ 119. Reviewing the Middle Cambrian fauna as a whole, we find that it combines the characters of both the Lower Cambrian and the Upper Cambrian faunas, and yet is distinct from either of them. There does not appear to be an equivalent fauna in the Cambrian system of Europe, either in Bohemia, the Scandinavian area, or in Wales. The nearest approach to it is on the island of Sardinia. (See close of remarks on the genus Ethmophyllum, p. 80.)

§ 120. The conditions that developed the Middle Cambrian fauna appear to have been largely peculiar to the American continent. During the deposition of the St. John series of the Lower Cambrian or the Paradoxides strata, we learn from the European and the eastern American sections that the fauna was essentially of the same type over the entire basin (Atlantic), and, from the evidence known to date, that the fauna did not extend west of a line passing northeast through Eastern Massachusetts to New Brunswick and Newfoundland.

§ 121. That there were deposits of sediments to preserve the fauna, if it extended westward, is shown by the thousands of feet of sediments below the Middle Cambrian faunas of Utah and Nevada.

§ 122. From the evidence we now have it appears to me that during the existence of the greater portion of the Lower Cambrian (Paradoxides) fauna a barrier existed that prevented its extension westward of the line mentioned (§ 120); that towards the close of the time of the Paradoxides fauna the barrier was removed to the northeast, and its descendants entered the westward seas and spread over the entire interior basin and formed the middle Cambrian fauna. In the Atlantic basin the Paradoxides fauna persisted to a greater or less extent, and mingled with the types of the Upper Cambrian fauna, as in the Upper Lingula Flags of Wales.

§ 123. If the strata of the Grand Cañon, Llano, and Keweenaw groups are of pre-Cambrian age or older than the strata carrying the Paradoxides fauna on the eastern side of the continent, and also older than the strata of the lower portion of the Wasatch section, another explanation is offered for the absence of the Paradoxides fauna in the central and western portions of the continent. During the period of erosion of the Grand Cañon, Llano, and Keweenaw Formations, a land surface probably extended from north of Lake Superior south to Central Texas and west, on the south, to the Grand Cañon region of Northern Arizona.

How much larger it was we do not know, but the orographic movement that brought the Grand Cañon, Llano, and Keweenaw Formations above sea level probably extended all along the central line of the continent, leaving the Atlantic area and the Great Basin of Utah, Nevada, Arizona, &c., areas of deposition during the existence of the Paradoxides fauna, and probably during the existence of the Middle Cambrian fauna, a break on the north or south permitting the latter fauna to pass into the western basin now covered by a portion of the Rocky Mountain area. At the time of the Middle Cambrian fauna the central land area of the Middle and Lower Cambrian epochs, or the Keweenaw land, was depressed beneath the sea and a series of strata deposited that now contains the Upper Cambrian fauna in all the localities where the strata of the Keweenaw land and of the Upper Cambrian show their relations to each other.

If this is a correct interpretation of the evidence now known, we may look in vain in the interior basin for the Paradoxides fauna of the Atlantic basin.

§ 124. That there was life in the older Cambrian or possibly in the pre-Cambrian seas of the interior basin there is no doubt, as we have found traces of it in the Grand Cañon Formation of Arizona; and the development of that fauna is one of the problems yet awaiting solution.

§ 125. During the Upper Cambrian (Potsdam of America, Upper Lingula Flags of Wales) the faunas of the two basins appear to have had free communication with each other, and we now find them with a more similar facies.

§ 126. The above views are more or less theoretical, but the facts demand an explanation other than that the faunas of the Lower, Middle, and Upper Cambrian were contemporaneous, but in different geographic areas. That the Upper and Middle faunas were separated by a great interval is shown by the sections, and that the Middle and Lower faunas were not contemporaneous is shown by the biologic evidence and the indirect evidence of the absence of the Lower fauna in association with the Middle fauna in the Newfoundland area, where they are now found, in different sections, a short distance from each other, but separated by faults and valleys of erosion, now filled by the sea.

§ 127. With the given facts there is little hesitancy in claiming for the Middle Cambrian (Georgia or Olenellus) fauna a distinct horizon in the Great Cambrian System of the American continent. That further research will result in discovering many connecting links between the Lower and Middle and Middle and Upper faunas of the system there is little, if any, doubt; but that the three faunas are not of the same geologic age appears to be now well established.

§ 128. Analytic comparisons with the Cambrian faunas of Europe are omitted until the study of the Upper Cambrian fauna is further advanced.

§ 129. If students discover errors in these preliminary studies of the

Middle Cambrian faunas, I will be glad to have my attention called to them. I also wish to obtain information of the occurrence of Cambrian fossils and of the places where perfect or rare specimens may be seen or obtained for study and illustration. Any information will be acceptable, and the completeness of the work and its value to the student will be increased by such assistance.

SUMMARY OF THE CAMBRIAN FAUNAS OF NORTH AMERICA.

§ 130. In the accompanying table a summary is given of the Cambrian faunas of North America, as far as known to me, up to the present date. A critical study of the Upper Cambrian faunas will eliminate some of the genera and species, and also add others. The study of the Lower Cambrian fauna of New Brunswick is now being carried forward by Mr. G. F. Matthew, and that of the Upper Cambrian by myself, and probably within two years the Cambrian fauna of North America will be known to include more than 100 genera and 400 species, as to-day there are 92 genera and 393 species published that I have included in the fauna. Besides these there are a number of genera and species not included that may not be based on organic remains or are synonyms of some of those that are included.

Summary of the Cambrian faunas of North America, by genera.

	Lower.	Middle.	Upper.	No. of genera.	No. of species.
ALGÆ.					
Cruziana	....	×-1	×-1	1	2
Palæochorda	....	....	×-1	1	1
Palæophycus	....	×-2	×-4	1	6
Totals	....	2-3	3-6	3	9
SPONGIÆ.					
Archæocyathus	? 1	× 3	....	1	4
Eocoryne	× 1	....	....	1	1
Ethmophyllum	....	× 4	....	1	4
Leptomitus	....	× 1	....	1	1
Protospongia	× 1	× 1	× 1	1	2
Strephochetus	....	× 1	....	1	1
Totals	3-3	5-10	1-1	6	13
HYDROZOA.					
Climacograptus ?	....	× 1	....	1	1
Dendrograptus	× 1	....	× 1	1	2
Diplograptus	....	× 1	....	1	1
Protograptus	× 1	....	....	1	1
Totals	2-2	2-2	1-1	4	5
CRINOIDEA.					
Eocystites	× 1	× 2	1-1	1	3
ANNELIDA.					
Arenicolites	? 1	? 1	× 2	1	4
Scolithus	....	....	× 1	1	1
Totals	1-1	1-1	2-3	2	5

Summary of the Cambrian faunas of North America by genera—Continued.

	Lower.	Middle.	Upper.	No. of genera.	No. of species.
BRACHIOPODA.					
Acrotreta	× 2	× 1	× 1	1	4
Acrothele	× 1	× 1		1	2
Camarella		× 2	× 1	1	2
Discina?			× 2	1	2
Iphidea		× 1		1	1
Kutorgina	× 2	× 4	× 2	1	8
Leptæna			× 2	1	2
Lingula?			× 3	1	3
Lingulella	× 3	× 2	× 3	1	8
Lingulepis			× 9	1	9
Linnarssonia	× 2			1	2
Obolella		× 5	× 4	1	9
Orthis	× 2	× 1	× 3	1	6
Orthisina		× 7	× 1	1	8
Triplesia			× 1	1	1
Totals	6–12	9–24	12–32	15	67
LAMELLIBRANCHIATA.					
Fordilla		× 1		1	1
GASTEROPODA.					
Bellerophon			× 1	1	1
Billingsia			× 1	1	1
Euomphalus			× 1	1	1
Harttia	× 1			1	1
Holopea			× 1	1	1
Maclurea			× 1	1	1
Metoptoma			× 1	1	1
Ophileta			× 1	1	1
Palæacmea			× 2	1	2
Platyceras		× 1	× 3	1	4
Pleurotomaria			× 1	1	1
Scenella		× 4		1	4
Stenotheca	× 6	× 2	× 1	1	9
Straparollina	? 1			1	1
Totals	3–8	3–7	11–14	14	29
PTEROPODA.					
Diplotheca	× 2			1	2
Hyolithellus		× 1		1	1
Hyolithes	× 5	× 6	× 3	1	14
Salterella		× 2		1	2
Serpulites			× 1	1	1
Totals	2–7	3–9	2–4	5	20
CRUSTACEA.					
Beyrichona	× 2			1	2
Climactichnites			× 1	1	1
Hipponicharion	× 1			1	1
Lepidilla	× 2			1	2
Leperditia		× 2	× 2	1	4
Lepiditta	× 1			1	1
Nothozoe			× 1	1	1
Primitia?	× 1			1	1

Summary of the Cambrian faunas of North America, by genera—Continued.

	Lower.	Middle.	Upper.	No. of genera.	No. of species.
CRUSTACEA—Continued.					
Protichnites			× 1	1	1
Protocaris		× 1		1	1
Totals	5–7	2–3	4–5	10	15
PŒCILOPODA.					
Aglaspis			× 2	1	2
Agraulos	× 5		× 10	1	15
Agnostus	× 8	× 3	× 15	1	26
Amphion?			× 1	1	1
Anopolenus	× 1			1	1
Anomocare		× 1		1	1
Arethusina			× 1	1	1
Asaphiscus		× 1		1	1
Bathynotus		× 1		1	1
Bathyurus?			× 12	1	12
Bathyuriscus		× 2		1	2
Chariocephalus			× 2	1	2
Conocoryphe	× 3			1	3
Crepicephalus		× 2	× 1	1	3
Ctenocephalus	× 1			1	1
Dicellocephalus			× 29	1	29
Illænurus			× 1	1	1
Mesonacis		× 1		1	1
Microdiscus	× 2	× 4	? 1	1	7
Ogygia?			× 1	1	1
Olenellus		× 4		1	4
Olenoides		× 8		1	8
Olenus			× 1	1	1
Oryctocephalus		× 1		1	1
Paradoxides	× 8			1	8
Pemphigaspis			× 1	1	1
Protypus		× 2		1	2
Ptychaspis			× 7	1	7
Ptychoparia (and subgenera)	× 6	× 14	× 60	1	80
Solenopleura	× 1	× 1		1	2
Triarthrella			× 1	1	1
Totals	9–35	14–45	16–146	31	226

Stratigraphic résumé.

	Genera.	Species.
Upper Cambrian	52	213
Middle Cambrian	43	107
Lower Cambrian	32	76
	127	396
Reappearances	35	3
Total fauna	92	393

Zoölogic résumé.

	Genera.	Species.
Algæ	3	9
Spongiæ	6	13
Hydrozoa	4	5
Crinoidea	1	3
Annelida	2	5
Brachiopoda	15	67
Lamellibranchiata	1	1
Gasteropoda	14	29
Pteropoda	5	20
Crustacea	10	15
Pœcilopoda	31	226
	92	393

§ 131. *Genera limited to the Lower Cambrian.*—Eocoryne, Protograptus, Linnarssonia, Harttia, Diplotheca, Beyrichona, Hipponicharion, Lepidilla, Lepiditta, Primitia ?, Paradoxides, Anopolenus, Conocoryphe, and Ctenocephalus.

§ 132. *Genera limited to the Middle Cambrian.*—Ethmophyllum, Leptomitus, Iphidea, Fordilla, Scenella, Hyolithellus, Salterella, Protocaris, Anomocare, Asaphiscus, Bathynotus, Bathyuriscus, Mesonacis, Olenellus, Olenoides, Oryctocephalus, and Protypus.

§ 133. *Genera of the Upper Cambrian not occurring in the Middle and Lower Cambrian.*—Palæochorda, Scolithus, Discina, Leptæna ?, Lingula, Lingulepis, Triplesia, Bellerophon, Billingsia, Euomphalus, Holopea, Maclurea, Metoptoma, Ophileta, Palæacmea, Pleurotomaria ?, Serpulites, Climacticlmites, Nothozoe, Protichnites, Aglaspis, Amphion ?, Arethusina, Bathyurus ?, Chariocephalus, Dicellocephalus, Illænurus, Ogygia ?, Olenus ?, Pemphigaspis, Ptychaspis, and Triarthrella.

§ 134. *Genera common to the Lower and Middle Cambrian.*—Archæocyathus, Protospongia, Eocystites, Arenicolites, Acrotreta, Acrothele, Kutorgina, Lingulella, Orthis, Stenotheca, Hyolithes, Agnostus, Microdiscus, Ptychoparia and subgenera, and Solenopleura.

§ 135. *Genera common to the Middle and Upper Cambrian.*—Cruziana, Palæophycus, Protospongia, Arenicolites, Eocystites ?, Acrotreta, Camarella, Kutorgina, Lingulella, Obolella, Orthis, Orthisina, Platyceras, Stenotheca, Hyolithes, Leperditia, Agnostus, Crepicephalus, Microdiscus ?, and Ptychoparia.

§ 136. *Genera common to the Lower and Upper Cambrian.*—Dendrograptus, Arenicolites, Eocystites ?, Acrotreta, Kutorgina, Lingulella, Orthis, Stenotheca, Hyolithes, Agraulos, Agnostus, Microdiscus ?, and Ptychoparia.

§ 137. *Genera common to the Lower, Middle, and Upper Cambrian*—Protospongia, Arenicolites, Eocystites ?, Acrotreta, Kutorgina, Lingulella, Orthis, Stenotheca, Hyolithes, Agnostus, Microdiscus ?, and Ptychoparia.

§ 138. Of the 52 genera in the Upper Cambrian, 17 may be said to be typical of the Second fauna, viz, Discina, Lingula, Leptæna, Orthis, Triplesia, Bellerophon, Euomphalus, Holopea, Maclurea, Metoptoma, Ophileta, Pleurotomaria, Hyolithes, Serpulites, Amphion, Bathyurus, and Ogygia. Of the above genera, Discina, Pleurotomaria, Amphion, Bathyurus, and Ogygia are doubtfully identified in the Cambrian. Several other genera pass up into the base of the Lower Silurian (Ordovician), but are not considered as typical of the Second fauna.

§ 139. When an accurate stratigraphic and paleontologic study is made of the passage beds between the Cambrian and Lower Silurian (Ordovician) systems, or the Potsdam and Calciferous Formations of the New York and Canadian sections, we shall possess the data upon which to compare the faunas of the two sections. At present this knowledge is, to a large extent, wanting.

CLASSIFICATION OF NORTH AMERICAN CAMBRIAN ROCKS.

§ 140. The following table expresses my view of the classification of the various formations that go to make up the Cambrian system of North America. It is subject to revision in details, but the main divisions are based on paleontologic and stratigraphic data that I think will render them of service in the permanent classification of American Paleozoic rocks.

The faunas of the Lower Calciferous unite the characters of those of the Upper Cambrian and Lower Silurian (Ordovician), and it will often be difficult to determine to which system the strata containing them should be referred.

Classification of North American Cambrian rocks.

UPPER CAMBRIAN.	Lower Calciferous.	Lower portion of the Calciferous Formation of New York and Canada. Lower Magnesian of Wisconsin, Missouri, &c.
	Potsdam. Knox. Tonto.	Potsdam of New York, Canada, Wisconsin, Texas, Wyoming, Montana, and Nevada; Tonto of Arizona; Knox Shales of Tennessee, Georgia, and Alabama. The Alabama section may extend down into the Middle Cambrian.
MIDDLE CAMBRIAN.	Georgia. L'Anse au Loup. Prospect.	Georgia Formation of Vermont, Canada, and New York. Limestones of L'Anse au Loup, Labrador. Lower part of Cambrian section of Eureka and Highland Range, Nevada. Upper portion of Wasatch Cambrian section, Utah.
LOWER CAMBRIAN.	St. John. Braintree. Newfoundland. Wasatch. Tennessee. ?	Paradoxides beds of Braintree, Mass., St. John, New Brunswick. St. John's area of Newfoundland. Lower portion of Wasatch section, Utah. The Ocoee conglomerate and slates of East Tennessee are somewhat doubtfully included.

The Grand Cañon, Llano, and Keweenaw series are probably of pre-Cambrian age, and are omitted from the Lower Cambrian, although I have heretofore made a provisional reference of them to the Cambrian.

§ 141. The first systematic arrangement of the formations of the Cambrian system of North America is that based on the paleontologic work of Mr. E. Billings by Sir William Logan. The Cambrian as a system is not recognized, the formations from the "St. John's group" to the Hudson River group, inclusive, being placed under the Lower Silurian. Owing to its historic interest and value as a contribution to stratigraphic geology, the table is given complete as found on page 46 of the Report of the Geological Survey of Newfoundland for 1865:

English Synonyms.	Complete series.	Western Basin.	Eastern Basin.	Newfoundland.
Caradoc	12. Hudson River	Hudson River		
	11. Utica	Utica		
	10. Trenton group	Trenton group		
Caradoc?	9. Chazy	Chazy		
Llandeilo	8. Sillery } Quebec group		Sillery	Sillery.
	7. Lauzon } Quebec group		Lauzon	Lauzon.
	6. Levis } Quebec group		Levis	Levis.
	5. Upper Calciferous			U. Calciferous.
Tremadoc	4. Lower Calciferous	L. Calciferous		L. Calciferous.
	3. Upper Potsdam	U. Potsdam		U. Potsdam.
Lingula flags.	2. Lower Potsdam	L. Potsdam?	L. Potsdam	L. Potsdam.
	1. St. John's group		St. John's group.	St. John's group.

In commenting on the table the author said:

It thus appears that the lower portion of the series is complete in Newfoundland and the upper in New York and Central Canada. Divisions 3, 4, and 5 have not yet been recognized in the eastern continental region.

The St. John's group, 1, is represented at St. John, New Brunswick, by 3,000 feet of black slates and sandstones, whose fauna, described by Mr. Hartt, was correctly referred by him to Étage C of Barrande's Primordial zone. It there reposes on older schistose rocks, as yet unstudied, but by Messrs. Hartt and Matthews designated as Cambrian. The slates of St. John's, Newfoundland, and the paradoxides beds of Braintree, Massachusetts, also probably belong to the same horizon.

The Lower Potsdam, 2, is represented by several hundred feet of limestones and sandstones on the Straits of Belle Isle and on White Bay, in Newfoundland, and by the slates of St. Albans and Georgia, Vermont.

The Upper Potsdam, 3, is that of Wisconsin and Minnesota, represented in the typical Potsdam of New York, which is overlaid by the Lower Calciferous, 4, while the Upper Calciferous, 5, is only recognized in the northern peninsula of Newfoundland.

In addition I wish to add that number 1 is the Lower Cambrian, number 2 the Middle Cambrian, and number 3 the Upper Cambrian of this paper. The additions made to our knowledge of number 2 since 1866 have been the discovery of the Georgia fauna about and below Troy, in the Hudson River valley, by Mr. S. W. Ford; the discovery of the same fauna at Eureka and at various other localities in Nevada and

Utah by the United States Government surveys; and at Kicking Horse Lake, British America, by the Canadian Geological Survey. In this paper I have endeavored to sum up the results of past work and my own investigations, and to establish, on a firmer stratigraphic and paleontologic basis, the Cambrian system of the Continent. The work is necessarily imperfect, but it clears the way for future investigation.

ON THE USE OF THE NAME TACONIC.

§ 142. Several American authors claim that the name Taconic should be used to include the strata characterized by the first or Primordial fauna of Barrande. If this is done, the term "Cambrian" will necessarily be dropped. In reading over the arguments, pro and con, respecting the use of Taconic, I have been influenced by a desire to do justice to the work of the author of the "Taconic System" and to retain a name proposed by an American geologist. It is with regret that I find myself compelled now to use Cambrian in preference to Taconic, especially as the Middle Cambrian fauna of this paper is the fauna of the Upper Taconic of Emmons, as defined by him in 1855 (Amer. Geol., pt. 2, pp. 49–69, 1855).

§ 143. There is no doubt that Dr. Emmons was correct in classifying the Upper Taconic as pre-Potsdam. To him belongs the credit of recognizing and describing the Middle Cambrian series of North America as a distinct formation both on structural and paleontologic grounds; and it is regretted that we cannot unite with Professors Marcou and Winchell in applying the name Taconic to the formation. If we do so, the great Lower Division, described by Dr. Emmons as the typical Taconic, will be dropped entirely, and the Upper Taconic, which is not now known to occur in the Taconic area, would be taken as the true Taconic, which it does not appear to be, although Dr. Emmons included the "Black Slate" in it in 1847.

§ 144. Dr. Emmons deserves great credit for the work that he did. Struggling under adverse circumstances, at a time when there was almost nothing known of the pre-Potsdam strata of North America, and when geologic methods were yet in their beginnings, he accomplished a work, in one of the most complicated regions of American geology, the central idea of which, that a great series of Paleozoic strata of pre-Potsdam age existed east of the Hudson River shales of the valley of the Hudson and Lake Champlain, we now know was correct. In the face of the almost united opposition of his contemporaries he maintained his position; and it is one of the misfortunes of his career that he began his work on the Taconic System in the Taconic area, instead of Western Vermont or along the Hudson River, as he would then have established his Upper Division first and given it a name under which the Cambrian series of the continent might have readily been assembled.

§ 145. It may be that when the entire extent of the typical Taconic area is thoroughly studied the representative of the great limestone belt beneath the shales of Georgia, Vermont, may be determined, and also the overlying Olenellus shales and the underlying strata. If so, no one will take greater pleasure in adopting the term Taconic, as equivalent to Cambrian and in place of it, than myself.

§ 146. The following extracts from Dr. Emmons's works, with running comments, are given to define the position of the two divisions of the Taconic System.

§ 147. Dr. Emmons, in proposing the Taconic System, said (Geol. New York, Surv. Second Geol. Dist., 1842, p. 136):

> The Taconic System, as its name is intended to indicate, lies along both sides of the Taconic range of mountains, whose direction is nearly north and south, or for a great distance parallel with the boundary line between the States of New York, Connecticut, Massachusetts, and Vermont. The counties through which the Taconic rocks pass are Westchester, Columbia, Rensselaer, and Washington; and, after passing out of the State, they are found stretching through the whole length of Vermont and into Canada as far north as Quebec. It is, however, in Massachusetts, in the county of Berkshire, that we find the most satisfactory exhibition of these rocks. They form a belt whose width is not far from fifteen miles along the whole western border, and which extends clearly to the western base of the Taconic Range. The greatest breadth, therefore, as will be seen by an inspection of any map of this section of country, is wider upon the eastern than upon the western side of this range. In Vermont they range along the upper members of the Champlain Group, and thus become connected with the Second district.

§ 148. In speaking of the "Position and relation of the Taconic System," he said further (p. 137):

> In this connection, I may state another result as the consequence of the geographical position of the Taconic System: it is the partial blending of the rocks of the three adjacent systems, the Primary of the Hoosic Ranges upon the east and the New York Transition System on the west with the Taconic, creating thereby many doubts and perplexities as it regards the true limits of either system; and inasmuch as the whole belt itself of the latter rocks is narrow, doubts are thrown over the whole as it regards the views we are to take of them. It will be more clearly seen in the following pages how it is that differences of opinion prevail in relation to these rocks. Where they have been crowded together, and especially where the masses are lithologically similar, it is not at all remarkable that the views and opinions of geologists should differ; besides, under the most favorable circumstances, the lines of demarkation between rocks of different eras are often extremely obscured, and cannot be drawn with that exactitude we wish, in consequence of concealment under the soil or other circumstances equally effective to render their extent and relations indistinct and uncertain.

§ 149. On the following page he again speaks of the difficulty of recognizing the differences between the Taconic series and the formations of the Champlain Group:

> Much difficulty is encountered, as has been already hinted, when we attempt to draw the line of demarkation between the shales and slates east of the Hudson River and Lake Champlain and the slates of the Taconic System. So nearly do the latter resemble the former in lithological characters that in specimens of small size the one might be mistaken for the other. But this is a common difficulty, or one common to all rocks of the same lithological characters, and it is not to be considered as a positive objection to the separation which I now propose.

There are two or three other points it may be well to state in this place: One is in regard to the condition of the country along the line of junction of these and of almost all other rocks: there is, for example, a concealment of the strata by rocks and earth for quite a wide space, covering the termination of the masses on either side; added to this difficulty is the confusion created by the great sameness in the direction of dip, and as both are lithologically slates or shales and both liable to certain changes in their planes of stratification and of deposition, a wide door is opened, through which we may run into mistakes and create confusion. In fact, it often happens that where either of these difficulties exists alone special care has to be taken to avoid error; but where they all appear, as in the instance under consideration, we can scarcely expect to escape falling into some gross mistake, that especially which concerns the designation of the rock.

§ 150. Dr. Emmons, after mentioning the question of the relations of the Taconic and Champlain Groups and deciding that they are made up of strata belonging to two distinct geologic systems, proceeds to discuss the lithologic characters of the series (pages 138, 139, 140), and says in conclusion (p. 140):

If the preceding views are admissible, there is sufficient reason for regarding the rocks which lie between the upper members of the Champlain Group and the Hoosic Mountain as a distinct series at least; but I would remark that by the expression "lying between" I have reference to geographical position, for, considered geologically, they can be regarded in no other light than as inferior to the Potsdam sandstone or as having been deposited at an era earlier than the lowest member of the New York Transition System. We have in no instance, however, been able to trace a connection in these masses, and we have never found the Potsdam sandstone resting upon any of the members of the Taconic System. To attempt to explain this remarkable feature or fact would be premature. The bare fact that the Potsdam sandstone rests on gneiss or granite, without the interposition of any other rock, we early pointed out, and, commencing our series with it, we find it to be unbroken and uninterrupted up to the Old Red Sandstone. But if we commence an examination at the foot of the Hoosic Mountain, which is gneiss, we pass over a series totally different from those of which we have just been speaking, and among which the Potsdam sandstone does not appear, neither a limestone which can be referred to those of the Champlain Group, or slate or shale which can be recognized as belonging to the New York System. If we are correct in this conclusion, if the Taconic rocks differ as much as has been represented from the Primary and also from the Transition series, then it appears necessary that we should adopt views at least somewhat analogous to those expressed in the preceding pages.

§ 151. On page 142 he again calls attention to the "liability to mistake the limestones of this system for those which lie adjacent" and the "difficulties in distinguishing the slate of the Taconic System."

§ 152. The first section given, illustrating the Taconic System, is on page 145, and extends from Petersburg, Rensselaer County, New York, to Adams, Massachusetts; and on plate xi of the volume five sections are given "explanatory of the Taconic System." In all of them we find on the east the Hudson River Group, represented as resting unconformably on the "Taconic slate," then the "Sparry limestone" next east, and in sections 2, 3, and 4 followed by the "Magnesian slate" of the Taconic Mountains, which is overlaid by the "Stockbridge limestone," &c.

§ 153. After describing the "Rocks of the Taconic System" in a general way the author then takes each formation up in detail, beginning with the western mass of slate which is denominated "Taconic Slate" (p. 150). It is the first member of the Taconic series described, and, I think, occupies the position assigned to it by its author as being older than the *Potsdam sandstone of New York, and unconformable to the* Hudson River shales.

§ 154. The Sparry limestone is next described, and then follows the "Magnesian Slates," the "Stockbridge Limestone," and the "Granular Quartz."

§ 155. On page 163 various conclusions of a general character are given, and in the eighth we find the "Taconic" correlated with the Lower Cambrian of Sedgwick:

> 8. The Taconic rocks appear to be equivalent to the Lower Cambrian of Professor Sedgwick, and are alone entitled to the consideration of belonging to this system, the upper portion (of the Cambrian) being the lower part of the Silurian System.

§ 156. The next extended publication by the author of the "Taconic System" is in the Agriculture of New York, vol. i, 1847. Dr. Emmons's view of the presence of a system of rocks older than the Lower Silurian of the New York section is evident from the following extracts (page 46):

> In the following pages I believe the reader will be satisfied that in these rocks we have, for this country at least, the true *paleozoic base*, and that in them exist those *organic forms which are strictly entitled to the designation protozoic.*
>
> This fact is found in the existence of peculiar fossils on both sides of the Atlantic, which, so far as discoveries have yet been made, are confined to the slates of the Cambrian and Taconic System; and now the great object of the writer is to show *that the above question has not been settled right or according to facts; or, in other* words, that the Taconic rocks are not the Hudson River slates and shales in an altered state or that all the Cambrian rocks are not Lower Silurian (p. 49).
>
> I shall take the broad and distinct ground that the Taconic System occupies a position *inferior to the Champlain division of the New York System, or the Lower Division of the* Silurian System of Mr. Murchison. In order to prove that this position is well chosen it will be necessary to refer the reader to localities where one system of rocks reposes upon the other, and that I might set this beyond the possibility of a doubt I have *sought those points where the slates of the Taconic System come in* contact with the lower limestones, or with the Potsdam sandstone of the New York System (p. 55).

§ 157. In the section (page 63, fig. 7) given as showing the position and order of the Taconic rocks, we find essentially the same order as in that of the report of 1842, and beneath it the author begins the description of the rocks composing the Taconic System with the description of *the black slate overlying the "Taconic Slate" and its contained fossils.* The "Black Slate" he considered as indicating a distinct rock from the Taconic Slate, and to be the highest member of the Taconic System. The fossils described are typical of the fauna preceding the Potsdam fauna, and occupy the stratigraphic position, in relation to the Potsdam series of New York, assigned them by Dr. Emmons.

§ 158. In giving its distribution he says (p. 71):

The Black Slate is not as well exposed as the Taconic; there is, therefore, some uncertainty in regard to it. It is the rock adjacent to the Champlain and Hudson Valleys, and more frequently that which we observe immediately beneath the calciferous sandrock, or cropping out from beneath it. What we see of it is frequently in a crushed condition, and bounding the Taconic Slate on the west in New York and Vermont. I have not recognized it about Albany or Troy. Greenwich, in Washington County, is the most southern point at which I have observed it. It extends north as far as St. Albans, in Vermont. I speak of those points which I have inspected. On St. Albans Bay it is traversed by satin spar. It is also calciferous here, as well as at numerous points upon Lake Champlain. It crops out beneath the calciferous sandstone at Sharpshins, near Burlington. I am unable to form an estimate of its thickness.

§ 159. Of the Taconic Slate of the 1842 report (section 6) he says (p. 72):

The Taconic Slate, with its subordinate beds, occupies almost the whole of Columbia, Rensselaer, and Washington Counties. It extends to the base of the Taconic range of mountains, which divides New York from Massachusetts and Vermont. Lying in its usual inclined position, if no repetitions of the same mass occur, it is of immense thickness. For example, from Lansingburg to the Sparry limestone in the eastern part of Hoosic, near the western bounds of Bennington, in Vermont, it is at least twenty miles in a direct line. Its dip varies from 45° to 70°. But admitting that the same mass reappears, it will still be found immensely thick. I have often examined it two miles perpendicular to its strike, and found no indication of repetitions. I leave it to a future opportunity to make an approximate determination of its thickness, or to others who may take up the subject.

Without doubt this immense rock admits of subdivisions; that is, it will probably be found proper to make those masses which I have treated as subordinate independent rocks, of which perhaps others still will be recognized of sufficient importance to merit the same distinction. In whatever light we may regard these minor points, there is no doubt that the quantity of matter in this slate exceeds that of all the members of the New York System put together.

The Sparry limestones and other strata to the east are next described.

§ 160. Dr. Emmons again gives a résumé of the Taconic System in 1855 (Amer. Geol., pt. 2). On pages 5 and 6 he says:

My first business is to sketch a picture of the oldest of the sediments as they are exhibited in a series which collectively constitute the Taconic System, and as it is developed in the Taconic ranges of Berkshire and the adjacent country immediately north and south.

*   *   *   *   *   *   *

The Taconic System has a clear and well-defined base, which is rarely obscured by passages into the primary schists, the pyroplastic rocks, sienites, or granites.

*   *   *   *   *   *   *

If my views are correct (and I have endeavored to sift them of error), we can go back no further; we have no older sediments.

*   *   *   *   *   *   *

The evidence of the existence of a system of rocks beneath and older than the Silurian System in this country rests on many well-determined facts. These facts are not all of equal importance; but those which are not direct serve to corroborate and sustain those which are. The facts which bear directly upon the evidence alluded to are superposition, succession, unconformability, and the presence of fossils distinct from those of the Silurian System.

§ 161. On page 12 we have the first proposition to divide the Taconic

System into two divisions, Upper and Lower; the Lower to include all the original Taconic of the 1842 and 1846 reports, with the exception of a portion of the Taconic Slate and the "Black Slate" of the 1847 report.

§ 162. The author describes the Upper Division of the Taconic rocks as consisting of numerous beds of slate alternating with shales, thin-bedded sandstones (some of which are coarse and brecciated), thin-bedded, bluish limestone more or less cherty and red, and brown and purple roofing slates. Sections are given that cross the Upper Taconic series at points from Highgate, in Northern Vermont, to Rensselaer County, New York. Some of the sections have been studied since Dr. Emmons examined them, and the fact has been ascertained that he did not, in many instances, recognize the series of north and south faults that break the continuity of the sections; but, after deducting all the errors, the Upper Taconic remains as a distinct formation beneath the horizon of the Potsdam sandstone.

§ 163. In 1859 Dr. Emmons again reiterated his views of the Taconic System in his little Manual of Geology. Under Taconic System (p. 81) we read:

> This system deserves the special attention of geologists, for two reasons: 1st. It is probably the base of the *sediments*. 2d. It is also probable that it is the *Palæozoic base*, and, in both respects, it must be regarded as the oldest series of the sedimentary class.
>
> This system is subdivided into *Lower* and *Upper;* the first consists of a conglomerate at the base, succeeded by silicious talcose beds of considerable thickness, in which there are frequently pebbles; next above are three thick beds of sandstone, separated by talcose slates; these are succeeded by the Stockbridge limestone. This is the marble of Berkshire County, Massachusetts, and which extends from the State of Vermont to Georgia. The Stockbridge limestone is succeeded by a mass of slate of great thickness, the upper part of which is suitable for roofing. The greatest thickness of the Lower Taconic rocks is about 5,000 feet. The upper quartz beds are often vitrified, while a lower one, still many hundred feet nearer the pyro-crystalline rocks, is a sandstone (p. 85).

The upper series we have just described (§ 162).

§ 164. Prof. J. D. Dana considers that most, if not all, of the strata included by Emmons in his original Taconic is of Lower Silurian (Ordovician) age. Dr. T. S. Hunt holds that the term Taconic should be restricted to the original or Lower Taconic of Emmons (Trans. Roy. Soc. Can., Taconic Question in Geology, vol. i, p. 217; vol. ii, p. 125, 1883–'84), a view that appears to be the correct one; and whether geologists will unite with Dr. Hunt, and call the series of strata next beneath the Cambrian Taconian, is a question that is not yet decided, as it is yet unproven whether such a group exists in the original Taconic area. It appears to exist in other localities where it was described by Dr. Emmons, and, if this is verified, the term "Taconic" or "Taconian" may receive a final resting place in American geologic nomenclature.

ACKNOWLEDGMENTS.

§ 165. To Dr. Alfred R. C. Selwyn and Prof. J. F. Whiteaves, of the Geological Survey of Canada, I am indebted for the use of a number of the typical specimens described by Mr. E. Billings, in studying the Bic Harbor and L'Anse au Loup faunas, and also for duplicate specimens of a number of species, without which I could not have identified several species from Vermont. Mr. Edward Hurlburt, of Utica, N. Y., kindly sent for study all of his collection of Georgia fossils from Vermont, including the beautiful relief-specimen of *Mesonacis Vermontana*. By an arrangement made with Mr. S. W. Ford, he made drawings of the type specimens described by him, several of which are reproduced in this bulletin. Mr. Ford also kindly permitted me to examine his collection at his home. In the collection and preparation of the material from Vermont and New York for study, I have been assisted by Mr. Cooper Curtice, of the Geological Survey. The original drawings are by Mr. J. L. Ridgeway when not otherwise mentioned.

DESCRIPTION OF THE MIDDLE CAMBRIAN FAUNA.

FUCOIDAL REMAINS, TRAILS OF ANNELIDS, ETC.

Mr. Billings described two species referred to the Algæ from the Georgia Group, *Palæophycus incipiens* and *P. congregatus* (Geology of Vermont, vol. ii, pp. 943, 944). Prof. Jules Marcou mentions the presence of a species of Oldhamia (Bull. Soc. Géol. de France, 3e sér., t. ix, p. 25, 1881); but after examining the specimen labeled by Professor Marcou, and now in the Museum of Comparative Zoölogy at Cambridge, Mass., and also examining great quantities of the shales at Parker's quarry, it seems that the so-called Oldhamia is the result of frost and water action, and is not of organic origin. The Chondrites spoken of by Prof. Marcou, and so labeled in the Museum of Comparative Zoölogy, owes its origin to fine rootlets penetrating between the layers of shales and staining them. Worm trails and borings are not of infrequent occurrence in the Georgia Group, but with the exception of a species of Cruziana, found east of Highgate Springs, and one in Nevada, and, possibly, the two species of Palæophycus described by Mr. Billings, nothing else that can be referred to the Algæ is known to me.

Dr. E. Emmons described a number of trails and doubtful fucoids from the "black flags and slates" of Rensselaer and Washington Counties, New York, and Waterville, Maine, which he considered to be from the Taconic System. Owing to their doubtful zoölogic character and the insufficient data upon which many of the species are referred to the Upper Taconic, I have omitted them from the present study, and will not include them in the fauna until collections are made from the typical localities and their stratigraphic horizon is determined.

When revising the Upper Cambrian faunas, I expect to illustrate the trails and fucoids of the Cambrian System, and will then discuss more fully those of the Middle Cambrian.

SPONGIÆ.

Genus ARCHÆOCYATHUS Billings.

Archæocyathus Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 944; Pal. Foss., vol. i, p. 3 and p. 354.

Original description.—"Turbinate, simple or aggregate; cup deep. The internal structure, so far as can be made out, consists of an inner wall, constituting the inner surface of the cup, and an external wall or epitheca enveloping the whole. Between the two walls are numerous radiating septa, the interseptal spaces being filled with poriferous or cellular tissue. It is highly probable that the inner wall is permeated by pores communicating with the interseptal tissue."

As Mr. Billings included in this genus the species now placed under the genus Ethmophyllum, it is necessary to emend the above description.

Description as emended: Body of sponge simple, elongate, cylindro-conical, concentrically corrugated; cup deep. Both surfaces with irregularly-disposed round or oval pores, some of which penetrate a short distance and others communicate with the canals of the interior. Interior structure a more or less irregular system of rounded and irregular passages or canals, many of them terminating as cul-de-sacs or little chambers in the mass of the skeleton.

On a longitudinal section the skeleton is seen to be arranged on arching tranverse lines and vertical, slightly-radiating lines. The minute structure of the skeleton is unknown. If spiculæ existed they have been destroyed by the crystallization of the calcareous matter now forming the skeleton in *A. Atlanticus;* but in *A. Billingsi* spiculæ occur in the interseptal spaces, the cup, and about the specimens, as seen in thin sections, that I think belonged to the species.

ARCHÆOCYATHUS ATLANTICUS.

Plate ii, figs. 1, 1*a*; pl. iii, figs. 1, 1*a*, *b*, 2, 2*a*.

Archæocyathus atlanticus Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 945; Pal. Foss., vol. i, p. 5.

Original description.—"The only specimen of this species in the collection is a fragment 4½ inches in length, 14 lines in diameter at the larger and 9 lines at the smaller extremity. Where the diameter is 11 lines the cavity of the cup is 4½ lines across, and the space between the walls 3 lines. Of the radiating poriferous septa there are about 60; they are so irregular that it is only in certain places in finely-polished sections that the radiated structure can be detected. On one side where the specimen is weathered the structure presents the appearance of a rather compact cellular tissue. The form appears to be elongate conical, gradually tapering, the surface marked by wide shallow encircling oblique annulations, from 3 to 6 lines distant from each other. The outer wall does not seem to be poriferous, but this appearance may be due to the crystalline condition of the rock into which it is converted."

On studying the type specimens, I observed a small projecting growth from the inner wall (pl. ii, fig. 1*a*) which had begun to show a central cavity and an inner and outer wall. None of the sections shows the fine vesicular structure so prevalent in *E. profundum*, but, in place of the regular septa and dissepiments, we find an irregular system of thick arched septa and vertical partitions, the openings between them forming an irregular system of passages or canals, many of which terminate as cul-de-sacs and others penetrate through the walls, affording communication between the interior and the cup and also between the outer surface and the interior.

In some specimens the interior structure is so irregular that no system of septa can be determined.

The specimens referred to this species from Silver Peak, Nevada, are separated by an interval of 3,000 miles from those at L'Anse au Loup, but I am unable to detect differences of specific value between them. Each has the annulated cylindrical form, pitted surface, irregular walls, the interior skeleton with the irregular system of septa, and vertical partitions with the round or oval system of passages running through and between them. Many of the smaller specimens are solid to the center, and may possibly be branches broken off from a central mass; but, so far as we know, all the specimens are simple and not branched. There is also a considerable variation in the mode of arrangement of the canals running through the interior, but I think all the specimens belong to one species.

Formation and localities.—Middle Cambrian, L'Anse au Loup; on the Straits of Belle Isle, Labrador; and Silver Peak, Nevada. Longitude 117° 20′ E., latitude 38° N.

ARCHÆOCYATHUS BILLINGSI n. sp.

Plate iii, figs. 3, 3*a–c*.

Body of sponge cylindro-conical, annulated; cup deep. Both surfaces with irregularly depressed, round or oval pores that penetrate through the walls. Outer walls united by arched, transverse septa that are strengthened by irregular vertical partitions subparallel to the outer walls. Numerous small pores penetrate the septa and afford communication between the interseptal spaces which, with the outer pores, gave a free circulation to the water. Skeleton of the walls, septa, and partitions calcareous, apparently solid. In the cup and in the interseptal spaces where spiculæ from without apparently could not enter, we find in thin sections numerous small, irregular spicula-like bodies which I think were the spiculæ of the sponge.

The relations of this species to *A. Atlanticus* are shown by the form and by the tendency in some specimens of the latter to develop transverse septa and vertical partitions subparallel to the walls. Specifically they differ, but generically they approach each other quite closely, as may be seen by comparing the figures on plate iii.

The species occurs in a purplish limestone, associated with *A. Atlanticus*, *Ethmophyllum profundum*, &c. The largest example is a fragment of an elongate cylindro-conical specimen. Its greatest diameter is 15^{mm}.

Formation and locality.—Middle Cambrian, L'Anse au Loup, Straits of Belle Isle, Labrador.

Genus ETHMOPHYLLUM Meek.

Ethmophyllum Meek, 1868. Amer. Jour. Sci. and Arts, 2d ser., vol. xlv, p. 62.
Archæocyathus Meek, 1868. Amer. Jour. Sci. and Arts, 2d ser., vol. xlvi, p. 144.
Archæocyathellus Ford, 1873. Amer. Jour. Sci. and Arts, 3d ser., vol. v, p. 213. Generic name proposed at end of description of *Archæocyathus ? Rensselaericus*.
Protocyathus Ford, 1878. Amer. Jour. Sci. and Arts, 3d ser., vol. xv, p. 124.

The original description of the genus by Mr. Meek is descriptive of the species rather than of the genus, as the latter embraces several species that vary in details. Mr. Meek's description will be found under *Ethmophyllum Whitneyi*, the type of the genus.

As now understood, the genus may be defined as follows: Body of sponge simple, elongate, cup-shaped, turbinate, clavate or cylindro-conical, curved or straight, vertically ribbed or lobed or concentrically corrugated, or both combined. Cup deep, sometimes more or less filled by a vesicular growth on the inner wall. Both surfaces with more or less numerous round or oval pores in vertical and horizontal rows that cross each other obliquely or at right angles. The pores usually penetrate through the walls; some may terminate in cul-de-sacs. Outer and inner walls united by transverse vertical septa that originate on the outer wall and extend inward, ultimately joining the inner wall. Septa usually poriferous, but sometimes no openings can be detected. Thin dissepiments may or may not cross the spaces between the septa. Septa 6 to 112 in number, as now known. Inner wall with or without a vesicular growth extending into the central cup. The series of septa and walls may be repeated again and again, or show only one series. Skeleton made up of fine branching spiculæ in one species (*E. Minganensis*), and undetermined in others, owing, probably, to the replacement of the parts by calcite.

Mr. Billings, in proposing the genus Archæocyathus, evidently included this type, but at the same time he included another generic form, *A. Atlanticus*, and followed the generic description with that species. The generic description is also more applicable to *A. Atlanticus*. (Geology of Vermont, vol. ii, 1861, p. 944.) The second species, *A. Minganensis*, is now placed under Ethmophyllum, and *A. Atlanticus* is taken as the type of the genus Archæocyathus, although Mr. Billings, in subsequent publications, evidently considered it a secondary species; inasmuch as he did not redefine the genus and as another generic name is needed to include one of the two genera placed under *Archæocyathus*, I prefer to limit the latter to its type species and use Mr. Meek's genus for the other, and thus avoid placing Ethmophyllum as a synonym of Archæocyathus and creating a new genus to include *A. Atlanticus*.

Archæocyathellus Ford, 1873, is generically identical with Ethmophyllum. Mr. Ford distinguished the latter genus by its straight form, longitudinally-ribbed exterior, and remarkable poriferous system. I find all these characters in *E. Whitneyi* and also the characters of *E. profundum*.

In studying the structure of *E. Whitneyi*, *E. Minganensis*, *E. profundum*, and *E. Rensselaericum* we find in all an outer poriferous wall connected to an inner wall by septa, the double walls forming a figure that is cylindro-conical, clavate, turbinate, or modified forms of all of these; the central space inclosed by the inner wall is usually open, but sometimes filled with a vesicular mass, or it may be a building of wall upon wall, as in the outer walls. This is shown by fig. 1*b* of plate i and fig. 1*c* of plate iv. The outer surfaces of *E. Minganensis* and *E. profundum* show, in large specimens, a concentric corrugation or undulation of the surface, but in the small and slender specimens this becomes less and less prominent, and in one 5^{mm} in diameter it is nearly lost. In *E. Whitneyi* broad undulations begin to show in specimens 10^{mm} in diameter, as seen in fig. 1, plate iv. The species grows much larger, but none of the larger specimens show the outer surface or form.

The longitudinal ribbing of the surface is prominent in young slender specimens of *E. Whitneyi*, and less so in specimens 10^{mm} or 15^{mm} in diameter. This is owing to the increase in the number of septa with the increase in size. The septa of *E. Rensselaericum* vary in number, and the external ribbing varies in a corresponding manner.

The poriferous system of *E. Rensselaericum* appears to be the same as that of *E. Minganensis* and *E. Whitneyi*, as far as known.

The genus Protocyathus was proposed for a specimen having on the outer wall a single row of large pores directly on the line of each septum, the septum opposite a row of pores bending around each pore. In fact they correspond, in position and form, to the pores of the inner wall. We have, from Troy, a specimen with the outer wall removed, that indicates a similar row of larger pores than the width of the septum. The probabilities are that they indicate openings in the outer wall, but of this there is no positive proof. Mr. Ford's type specimen is a cast, nearly all the outer wall being removed, but on a small bit, still remaining, a poriferous surface is shown.

As far as I know the types of the two genera Archæocyathellus and Protocyathus, I refer them to Ethmophyllum, leaving the question of their specific relations an open one. The variation in the number and in the size of the septa is so great in *E. Rensselaericum* that it will not be surprising to find specimens showing gradational forms between the two species.

A specimen of *E. Whitneyi*, examined since the above was written, shows the poriferous outer wall removed in places and the larger openings on the lines of the septa (fig. 1, pl. iv). Comparing these with fig. 3, pl. ii (*E. profundum*) and other specimens, we find that this is owing to the openings in the septa just within the outer wall, as shown in a restoration (fig. 2, pl. iv). In fig. 2*b*, pl. v, the outer wall is removed and the openings look like pores leading into the interior. Fig. 2 also shows the same feature.

Mr. Billings, in describing the characters of the genus Archæocyathus, as found in *E. profundum*, *E. Minganensis* and *A. Atlanticus* (Pal. Foss., vol. i, p. 354, 1865), says:

"The following are some additional details of the structure of this remarkable genus: The general form, as exhibited by the three species at present known, is that of an elongated hollow cone, or, rather, a hollow cylinder with one end narrowed to a point, the smaller extremity being closed and more or less curved; the larger end open. They thus resemble certain large species of *Zaphrentis* or *Cyathophyllum*, and, in fact, from their form and septate structure, were at first thought to be corals. Some of the individuals appear to have obtained a length of two or three feet, with a diameter of three or four inches.

"All of the species are transversely and more or less deeply marked by irregular annulations. The structure consists of an inner thin wall or endotheca, lining the great central cavity, an outer wall or epitheca, forming the rough external surface, and between these a system of radiating septa. The outer wall in two of the species, *A. profundus* and *A. Minganensis*, is perforated with numerous small irregular apertures leading directly into the loculi or empty spaces between the septa. In the third species, *A. Atlanticus*, it (the outer wall) appears to have a

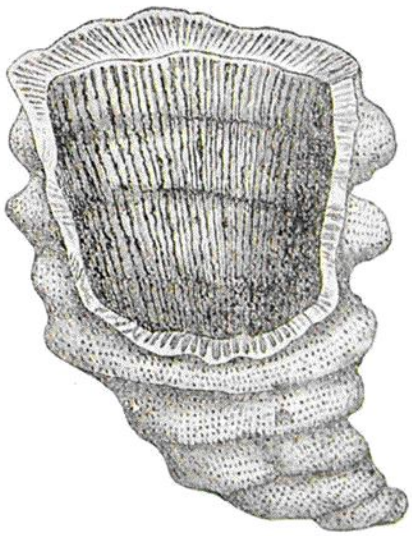


FIG. 6.

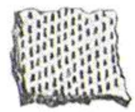


FIG. 7.

FIG. 8.

FIG. 6. Ethmophyllum Minganensis (after Billings).
FIG. 7. Ethmophyllum Minganensis (enlargement of surface).
FIG. 8. Ethmophyllum Minganensis (spiculæ, enlarged to 50 diameters).

compact, smooth surface, with only a few perforations. The inner wall is very thin, with numerous pores leading from the loculi into the great central cavity. The septa consist of thin, flat plates, arranged longitudinally exactly as in the genus *Zaphrentis*. They extend from the outer to the inner wall and are perforated with numerous small circular pores, so that the interseptal loculi all communicate with each other as well as with the central cavity and the exterior. The loculi are subdivided by very thin dissepiments resembling those of a *Cyathophyllum*, but they are irregularly distributed, being in some parts entirely absent and in other places so numerous that they completely fill the loculi with small cells, constituting the 'poriferous or cellular tissue' mentioned in the original description of the genus. The central cavity extends nearly the whole length and constitutes a large proportion of the bulk of the fossil. Below it there is a portion of the smaller extremity or base, which is composed only of the outer wall, the septa, and the dissepiments. The section across this part shows that the new septa, which are introduced from time to time, as the diameter increases, do not at first extend to the center, and it would appear from this that they were developed on the inner surface of the outer wall, and gradually widened as in the genus *Zaphrentis*. Close to the extreme point of the base the septa and dissepiments have an irregular arrangement, and the loculi sometimes here appear to be mere circular perforations.

"The small branching spicula, above figured, are seen imbedded in and forming a part of the substance of the outer wall of *A. Minganensis*. The fusiform and cylindrical varieties are also seen, but rarely, either adhering to or partially imbedded in the same specimens. As they were obtained in thousands in the sediment left after dissolving pieces of the limestone holding fragments of this species, they were at first thought to belong to it; but I have recently, while treating other pieces of limestone from the same bed, also holding fragments of *A. Minganensis*, found that another large species, *Trichospongia sericea*, occurs in this rock, portions of which are crowded with, and seem to be almost altogether composed of, these spicula. It should therefore remain an open question whether or not these fusiform and cylindrical spicula actually form a part of the structure of *Archeocyathus* or are those of *T. sericea*. There can scarcely be any doubt about the branched spicula, as they can be seen not only projecting from the surface of the silicified specimens, but also in the thin slices prepared for the microscope. No spicula have been detected in *A. profundus*. In *A. Atlanticus* there are several objects visible, in the only specimen of that species that has been collected, which resemble branched spicula. No silicified specimens of these two latter species have been procured, and I think it probable that if such could be examined spicula would be found in them.

"As to the zoölogical rank of this genus there yet remains some doubt. The general structure is such that it may possibly be a sponge. The apertures in the external wall may be the homologues of the inhalent pores of the ordinary sponge, while those of the inner wall may represent the exhalent orifices. The great internal cavity in that case would have the same function as the large central cloaca of the fistulose genera of sponges. A radiated and more or less perfectly septate structure occurs in many undoubted sponges. In this genus, however, the substance of the septa is almost as compact as that of the true corals. The perforated character of the outer wall, and also of the septa, suggest a comparison with corals of the division *Zoantharia perforata*. The *Favosites* have also their walls perforated. Dr. J. W. Dawson, who has examined a number of the slices of *A. atlanticus* and *A. profundus*, which have been prepared for the microscope, is of opinion that the structure of these two species is similar to that of the Foraminifera (Can. Nat. and Geol., April, 1865). My own opinion is that all three species belong to one generic group closely related to *Calathium*. This latter passes into *Eospongia*, which, in its turn, gradually merges into other genera that occur in more recent formations, such as *Rhysospongia*, *Scyphia*, *Siphonia*, and others. The resemblance between the whole structure and that of the palæozoic corals seems also to show that in the Lower Silurian seas organic forms existed combining the characters of the Protozoa and the Cœlenterata."

Sir J. W. Dawson compares the genus with Eozoön and gives additional particulars resulting from his study of the genus. He says (Dawn of Life, pp. 151–156, 1875): "To understand Archæocyathus let us imagine an inverted cone of carbonate of lime from an inch or two to a foot in length, and with its point buried in the mud at the bottom of the sea, while its open cup extends upward into the water. The lower part buried in the soil is composed of an irregular acervuline network of thick calcareous plates, inclosing chambers communicating with one another. Above this, where the cup expands, its walls are composed of thin outer and inner plates, perforated with innumerable holes, and connected with each other by vertical plates, which are also perforated with round pores, establishing a communication between the radiating chambers into which they divide the thickness of the wall. In such a structure the chambers in the wall of the cup and the irregular chambers of the base would be filled with gelatinous animal matter, and the pseudopods would project from the numerous pores in the inner and outer wall. In the older parts of the skeleton the structure is further complicated by the formation of thin transverse plates, irregular in distribution, and where greater strength is required a calcareous thickening is added, which in some places shows a canal system like that of Eozoön. (On the whole these curious fossils, if regarded as foraminifera, are most nearly allied to the Orbitolites and Dactyloporæ of the early Tertiary period, as described by Carpenter). As compared with Eozoön the fossils want its fine perforated wall, but have a more regular plan of growth. There are fragments in the Eozoön limestones which may have belonged to structures like these, and when we know more of the deep sea of the Primordial we may recover true species of Eozoön from it or may find forms intermediate between it and Archæocyathus. In the mean time I know no nearer bond of connection between Eozoön and the Primordial age than that furnished by the ancient cup Zoöphytes of Labrador, though I have searched very carefully in the fossiliferous conglomerates of Cambrian age on the Lower St. Lawrence, which contain rocks of all the formations from the Laurentian upwards, often with characteristic fossils. I have also made sections of many of the fossiliferous pebbles in these conglomerates without finding any certain remains of such organisms, though the fragments of the crusts of some of the Primordial trilobites, when their tubuli are infiltrated with dark carboniferous matter, are so like the supplemental skeleton of Eozoön that but for their forms they might readily be mistaken for it, and associated with them are broken pieces of other porous organisms which may belong to Protozoa, though this is not certain."

Zittel thinks that the genus may possibly be referred to his family Euretidæ (Handbuch der Pal., 1880, p. 173), and Hinde considers their relations as doubtful (Cat. Foss. Sponges, 1883, p. 10).

From the material we have for examination I am inclined to consider Ethmophyllum a sponge, the spiculæ of which, in several of the species, have been lost in the crystallization of the calcite now forming the skeleton. Its mode of growth and the development of the septa point to the cyathophylloid corals; the interior skeleton recalls some of the foraminifera, but the presence of spiculæ in *E. Minganensis* and the intimate relationship between all the species and *E. Minganensis* associate it with the Spongiæ, close to the family Euretidæ of Zittel. It may be necessary to establish a new family to receive this and allied genera.

Dr. Zittel defines the family Euretidæ as follows (Handbuch der Pal., p. 173, 1880): "Sponge-body cup-shaped, cylindrical, clavate or branching, fixed. Skeleton reticulate, the crossing nodes of the six-rayed, cemented spiculæ imperforate. External surface naked or protected by a thickening of the outer layer of the skeleton; sometimes covered with a very delicate network of cemented spiculæ which differ but little from those of the rest of the skeleton. This mesh-like covering also extends over the ostia (mouths). Structure of the root like that of the rest of the sponge. Spiculæ of the sarcode wanting or present."

I have recently become acquainted with the work of Dr. J. G. Bornemann of Eisenach, on the Paleontology of the Cambrian District of Canalgrande in Sardinia. That writer discusses the character of the fossils referred to the genus Archæocyathus and proposes a new class of Cœlenterata which he calls Archæocyathinæ. The genus Archæocyathus, as defined by Dr. Bornemann, is the genus Ethmophyllum of Meek. Nine species are described under it, most of which, it appears to me, are founded on varietal rather than specific characters.

The second genus, Coscinocyathus, is separated from Ethmophyllum (=Archæocyathus) by the presence of quite regular cross-septa, in addition to the longitudinal radial septa. This definition would include our species *E. Billingsi*. Fifteen species are described under Coscinocyathus, many of which are based on external form.

The third genus is Anthomorpha, in which there are irregular cross septa between the radial septa.

The descriptions are only outlined, and, as I have not seen either illustrations or specimens, I wait until Dr. Bornemann publishes his illustrated memoir before comparing or criticising the species.

The principal papers published by Dr. Bornemann, known to me at present, are:

Sur la Classification des Formations Stratifiées Anciennes de l'Île de Sardaigne. (Compte-Rendu du 2me Congrès géol. internat., Bologne, 1881, pp. 1–12, pls. i, ii.)

Palaeontologisches aus dem cambrischen Gebiete von Canalgrande in Sardinien. (Zeits. deutsch. geol. Gesellsch., xxxv., 2, 1883, s. 270–274.)

Cambrische Fossilien von der Insel Sardinien. (Zeits. deutsch. geol. Gesellsch., xxxvi., 3, 1884, s. 399–400.)

Untersuchungen cambrischer Archæocyathus-Formen und verwandter Organismen von der Insel Sardinien. (Zeits. deutsch. geol. Gesellsch., xxxvi., 3, 1884, s. 702–706.)

ETHMOPHYLLUM WHITNEYI Meek.

Plate iv, figs. 1, 1*a*–*h*.

Ethmophyllum Whitneyi Meek, 1868. Amer. Jour. Sci. and Arts, 2d ser., vol. xlv, p. 62.
Ethmophyllum gracile Meek, 1868. *Idem.*
Archæocyathus Whitneyi Meek, 1868. Amer. Jour. Sci. and Arts, 2d ser., vol. xlvi, p. 144.
Archæocyathus gracilis Meek, 1868. *Idem.*

Original description.—"The specimens of this fossil contained in the collection are slender, slightly flexuous, arched or nearly straight, and subcylindrical, excepting near the lower end, where they taper to a point, by which they were probably attached. They may have grown in tufts or groups, but all the specimens yet seen are single and show no evidences of growing in contact.

"To the unassisted eye the external surface of these corallites, with the exception of obscure annular swellings and constrictions of growth and faintly marked linear septal costæ, seems to be nearly or quite smooth. When examined under a strong lens, however, it is seen to be beautifully punctate, the punctures being minute, of exactly uniform size, and arranged with mathematical regularity in quincunx, and so closely crowded that the little divisions between them are scarcely equal in breadth to the punctures themselves, and form, as it were, an extremely delicate kind of net work. So remarkable is the appearance of this punctured outer wall that the first question that suggests itself, on examining it under a magnifier, is, whether or not it may be merely an exceedingly delicate Polyzoön incrusting the whole surface. A clear examination, however, especially in carefully prepared transverse sections, shows that the punctures actually pass entirely through the wall, which is very thin, and that they are not due to the growth of the Polyzoön, nor to surface ornamentation.

"On grinding away this very thin punctured wall, the septa are seen immediately within to be stout, equal, straight, and very equidistant, but in grinding a little farther in they are observed to become very regularly waved laterally, *exactly like the septa in the foraminiferous genus Fusulina*. So striking is this resemblance that it was not until after ascertaining from cross-sections that the fossil has not an involuted structure that I could get rid of the suspicion that it might be a type of *Foraminifera* allied to *Fusulina*, instead of an extraordinary coral.

"By grinding still farther in (to a depth of about 0.06 inch, in a specimen 0.34 inch in diameter), the lateral waving of the septa already mentioned is seen to be there suddenly and so strongly marked that they connect laterally in such a manner as to form a kind of complex inner wall between the great central cavity and the outer septate zone. This wall, however, does not completely isolate the septate outer zone from the central cavity, but is perforated by a series of round equal canals, very regularly placed, one within each of the lateral curves of the septa, so that those on the opposite sides of each septum alternate with exact regularity, as do those of each of the two rows within each interseptal space. These canals have no similarity to the minute punctures of the outer wall, being greatly larger and very differently arranged. They do not pass *directly* through the inner wall, but are directed obliquely upward and inward, so that as seen in transverse sections of the corallites they present the appearance of a double row of vesicles cut across.

"Both longitudinal and transverse sections show the large central cavity to be without any trace of septa or columella. From these sections I was likewise at first led to believe this central portion to be also an entirely open cavity or calice the whole length of each corallite, but on sending specimens to Professor Verrill he called my attention to some obscure appearances of transverse plates in one of the specimens cut longitudinally and requested me to cut others with the view of ascertaining whether or not these are plates. A longitudinal section of another specimen, however, when carefully polished, reveals no traces of proper transvere plates; but when examined by the aid of a strong magnifier it shows the whole interior to be occupied by a dense vesicular tissue, the walls of the vesicles being of extreme tenuity. This structure is seen in the interseptal spaces of the outer zone, as well as in the central cavity within.

"In regard to the affinities of so remarkable a type, it seems scarcely safe to express an opinion without a better series of specimens for study. Some of its internal characters, as suggested by Professor Verrill, would seem to indicate remote affinities to the *Cyathophyllidæ*; but its peculiar perforated outer wall would, on the other hand, appear to remove it from the primary division of corals including that family.

"I am therefore led to believe it a new genus, and most probably typical of a new family, in which opinion Professor Verrill concurs with me. For this genus I would propose the name *Ethmophyllum*.

"Among the specimens in the collection under examination there are apparently two species of this fossil. That considered the type of the genus is larger and more robust than the other, and more conical in form, especially near its smaller end. None of the specimens seen are quite perfect at the larger extremity. One measures 0.37 inch at its imperfect larger end and seems to have been 2½ to 3 inches in length. In this there are sixty septa, while its outer septate zone is 0.07 inches wide. Another fragment, however, measures 1.20 inch in diameter at the larger end, and was probably 5 to 6 inches or more in length, with 112 septa at the larger end. This large fragment shows that the septate outer zone does not increase in thickness or breadth in proportion with the size of the corallites, since it is only 0.15 inch broad in this specimen, the increase in thickness of this corallite being made up by the increased size of the non-septate interior. For this larger species I would propose the name *Ethmophyllum Whitneyi*, in honor of Prof. J. D. Whitney, to whom I am indebted for the use of the specimens.

"Of the other species I have seen but a single specimen, which is imperfect at both extremities, about 2.15 inches in length, and only about 0.20 inch in diameter at the larger end and 0.15 at the smaller, with some 24 to 28 septa. In addition to its much more slender form, it differs from the other species in having its septa so strongly waved laterally as almost to divide the interseptal spaces into cells, nearly to the outer wall. For this, if it should prove to be a distinct species, I would propose the name *Ethmophyllum gracile*."

A few months later Mr. F. B. Meek wrote Prof. Dana respecting the genera Ethmophyllum and Archæocyathus, and his remarks were printed as follows (Amer. Jour. Sci. and Arts, 2d ser., vol. xlvi, p. 144):

"Since preparing my remarks, published in the Journal of Science (Jan. number, p. 62, 1868), on the curious fossil from Nevada, for which I proposed the name *Ethmophyllum*, I have been led, by further comparisons, to think it probably not generically distinct from *Archæocyathus* of Billings. At any rate, it seems to agree *very* closely in internal structure with his *A. Minganensis* and *A. profundus*. The Nevada species differs so widely in form and general appearance as scarcely to suggest a comparison with Mr. Billings's species, and, besides, I had derived my impressions of his genus entirely from his typical species, *A. Atlanticus*, which also differs so materially in internal structure that Mr. Billings suspected it might be generically distinct from his *A. Minganensis*. If these types are generically identical, however, I can scarcely entertain a doubt but that the Nevada fossil will fall into Mr. Billings's genus, which has priority of date. In this case, the names of the Nevada species would become *Archæocyathus Whitneyi* and *A. gracilis*."

The original specimens described by Mr. Meek are in the collection of the United States National Museum, and a number of thin sections have lately been made from some of them that show the details of structure. An examination proves that the type species is generically the same as *Archæocyathellus Rensselaericus* of Ford, and that it is generically identical with *Archæocyathus profundus* of Billings. The septa join the inner wall regularly when there is no vesicular structure within it, but when the latter is present the septa terminate irregularly and the inner wall is imperfectly developed. In the lower and smaller end both walls and septa are regular, the vesicular structure and irregular growth coming in with the growth of the individual. The structure is shown by the figures of plate iv.

Sometimes the outer wall and septa are broken away, leaving the vesicular interior. I find that the form described as *E. gracile* by Mr. Meek is the result of such an accident, as it corresponds in structure to the vesicular interior of other specimens of *E. Whitneyi.*

We also observe that the thin arched dissepiments between the septa increase in number with the growth, and that where two dissepiments partition off a cavity between the septa a pore opens into it through one of the adjoining septa. The number of septa in sections of the same diameter varies considerably, eight to fourteen in sections $1\frac{1}{5}^{mm}$ in diameter. The thickness and direction of the septa are also variable in different specimens and in different parts of the same specimen. Frequently the differences might be taken to be of specific value, but I regard them as variations of growth caused by local influences on the individual sponge, such as being crowded by its fellows, fragments of other organisms getting into it, variation in supply of food, &c.

In a thin section, tubes two-fifths of a millimeter in diameter appear as simple rings crossed by light bands, which are the interseptal spaces. In other small sections the entire section is solid.

As the genus Archæocyathus is restricted to the type species *A. Atlanticus*, *E. Whitneyi* falls back into the genus proposed for it.

Formation and locality.—Middle Cambrian. Silver Peak, Western Nevada. The species occurs in a limestone and calcareous shale, associated with *Archæocyathus Atlanticus*, *Hyolithes princeps*, *Olenellus Gilberti*, &c.

ETHMOPHYLLUM PROFUNDUM Billings.

Plate 1, figs. 1*a–c*; pl. ii, figs. 3, 3*a*, *b*; pl. iv, fig. 3.

Archæocyathus profundus Billings, 1865. Pal. Foss., vol. i, p. 4.

Original description.—"Elongate, turbinate, more or less curved, the basal one or two inches slender, then rapidly expanding to a diameter of from one to four inches, then becoming cylindrical. The form is that of a large *Cyathophyllum* or *Zaphrentis.* The cavity of the cup extends in depth nearly to the base. The radiating septa are thin and closely crowded together, there being eight or ten in the width of three lines. The surface is annulated by strong rough ridges from three to six lines distant from each other, the intervening furrows being two or three lines deep. The inner wall of the cup is exceedingly thin, apparently less than half a line.

"In none of the specimens is the outer wall preserved except in spots, and there only partially. The large individuals appear to have attained a length of more than one foot with a diameter of from two to four inches."

Having received from the Geological Survey of Canada some fragments of limestone containing specimens of this species, several thin sections were prepared, from which illustrations have been taken that show most beautifully the manner of growth and the minute structure of the organism so far as preserved. The vesiculose character of portions of the structure give it the appearance of a Cystiphylloid coral. Beside the cup-shaped mode of growth, there are small stems 5^{mm} to 10^{mm} in diameter that are solid to the center, and one piece 20^{mm} in diameter has no central opening. In such examples the septa and dissepiments are thicker than in the examples with a central opening.

In the enlarged section of a sponge, shown by fig. 1, pl. i, and fig. 3, pl. iv, the growth has been a combination of the regular double walls with vertical septa and the vesiculose structure shown by fig. 1*d*, pl. i. The septa exist between several different, more or less entire, inner walls, and the thin arched dissepiments crowd all the open places between the septa and the irregular breaks in the walls. The specimens represented by figs. 1*b*, 1*c*, pl. i, show the irregular vesiculose structure carried to the extreme, the central cup being filled up for some distance. The outer wall, with its attached vertical septa, appears to have been broken or worn off of the specimens represented by figs. 1, 1*b*, of pl. i. This is not an uncommon feature of the specimens from L'Anse au Loup, and is very misleading in studying cross sections, as the irregular vesiculose interior often resists destruction better than the exterior, and an entirely different species appears to exist. Mr. Meek was misled by this in proposing *E. gracile* for the center of *E. Whitneyi*.

Formation and locality.—Middle Cambrian. L'Anse au Loup, Straits of Belle Isle, Labrador.

ETHMOPHYLLUM RENSSELAERICUM Ford.

Plate v, figs. 1, 1*e*–*f*.

Archæocyathellus? Rensselaericus Ford, 1873. Amer. Jour. Sci. and Arts, 3d ser., vol. v, p. 211, fig. 1. Genus Archæocyathellus proposed at end of description.

Original description.—"The only specimen clearly belonging to this species that has come under my notice is exceedingly small, being only 0.30 of an inch in length and having a diameter of not more than 0.16 of an inch at the larger extremity, when perfect. This specimen is, in appearance, a slender, delicately-fluted cone, about one-third of which, including the apex, is imbedded in the rock. Of the remainder a considerable portion is in a badly-damaged condition, the outer wall, with the greater part of its underlying septa, having been partially torn away. Such portion as remains uninjured, however, is in an excellent state of preservation and shows the leading features of structure in a very perfect manner. There remains, notwithstanding, much yet to be desired in order to completely characterize the species; and I have deferred any special notice of it hitherto in the hope of being able to obtain other, and possibly more perfect, specimens; but, failing in this, I have thought it advisable to carry the description as far at this time as the material at hand will permit. The species may be described for the present as follows:

"Elongate, conical, straight, gradually expanding from the base upward. Cup moderately large, depth unknown. Outer wall thick and strong, inner wall apparently much thinner. Radiating septa thin, numerous, not far from forty, judging from the number seen, sometimes a little irregular in their spacing. Dissepiments slender, occasionally absent, at other times dividing the interseptal spaces or loculi for a short distance into several compartments. Surface faintly annulated and longitudinally marked by numerous low, rounded ridges, with shallow intervening furrows, the ridges and furrows of about equal width. The ridges mark the position of the loculi, while the middle of each furrow indicates the place of one of the septa. Along each furrow and running its entire length are two straight rows of minute, closely-arranged circular pores, opening into the loculi. The rows of pores of any given furrow are separated from each other by a thin strip or plate of the outer wall, corresponding in position and thickness to the septa; and it is a singular fact that the pores of either row are arranged alternately not only with respect to the other, but also with respect to those of the succeeding row in the next nearest furrow. The pores all communicate with the interior close to the septa where these latter join the outer wall; and, as the rows of pores along any given furrow lead into distinct though adjacent loculi, it follows that all of the loculi were connected with the general surface by means of a double set of apertures. Whether the inner wall and radiating septa are perforate has not yet been made out. Color of the fossil, in gray limestone, when a little weathered, light brown.

"The above are the characters, so far as known, of this interesting and beautiful species, embracing only such as are displayed by the specimen mentioned at the beginning. These characters taken together are quite sufficient to distinguish it readily from any described species while in respect to several of them, such as its straight form, longitudinally-ribbed exterior, and remarkable poriferous system, the species appears to me at present sufficiently distinct from *Archæocyathus* to constitute a new though closely allied genus. Should a further study of it confirm this opinion, I propose to call it *Archæocyathellus.* Until, however, more can be said about it, I prefer to class it as above."

Having obtained more perfect specimens I add to the above description.

There are from three to six rows of minute pores on each of the slightly raised longitudinal lobes formed by the slight depression along the line of each septum. The entire surface is poriferous, and some of the rows of pores open directly on the line of the septum. This must influence in a measure the attachment of the septum to the outer wall.

The inner wall has a row of large pores, some of which are opposite the line of attachment of the septa and others open directly into the interseptal spaces.

The number of septa varies from nine to eighteen in the specimens we have; the type specimens, figured by Mr. Ford, show twenty or twenty-one. In most examples the septa are thin, but in one they are considerably thickened, as well as the outer and inner walls, the interseptal spaces being much reduced in size. That the septa are perforate where they join the outer wall is seen in the several examples; a diagrammatic sketch of this is shown by fig. 2, pl. iv.

The cup is very deep and extends nearly to the smaller end, which is closed or rounded off, terminating rather abruptly.

Mr. Ford states that several dissepiments divide the interseptal spaces, but none has been observed in the half dozen sections I have studied.

Formation and locality.—Middle Cambrian. Conglomerate limestone on the ridge east of the city of Troy, N. Y.

ETHMOPHYLLUM RARUM Ford.

Plate v, figs. 22*a–b*.

Protocyathus rarus Ford, 1878. Amer. Jour. Sci. and Arts, 3d ser., vol. xv, figs. 1*a*, *b*, p. 124.

Original description.—"The fossil form for which the above generic and specific names are proposed belongs to the *Archæocyathus* group and finds its nearest analogue in *Archæocyathellus* of the writer, from the same locality and geological horizon (this Journal, March, 1873). The only specimen at present known to me is but 0.22 of an inch in length and has a width of only 0.16 of an inch at the larger extremity. The general form is that of a minute cone with the apex broken off. The width at the smaller extremity is 0.12 of an inch, and of this fully one-third is occupied by the cup. The cup itself is filled with light-colored limestone, rendering it easily distinguishable from the interseptal areas, which are filled with a darker colored material. These latter appear to have been twenty-eight in number. The radiating septa may be observed in two or three places, and are seen to be thin and delicate. The outer wall has been almost wholly removed and the portions of it that remain are much weathered. The material presented for study consists, therefore, of the solid molds of the interseptal spaces, the cup filled with limestone, a small number of the septa, a transverse section of the inner wall, and the impression of a considerable portion of the outer wall. The latter shows that the external surface when perfect was longitudinally furrowed as in *Archæocyathellus*. In that genus, however, so far as known, there are two rows of pores along each of the furrows, one on either side of the septa, whereas in the present genus there appears to have been but one, and that placed directly on the line of the septa. The evidence of this consists of rudely circular holes placed at regular intervals along the middle of each furrow in the cast. These appear to me to argue the existence of funnel-like projections inward of the outer wall at the place of the openings. That they mark the position of orifices leading into the interior appears to me in the highest degree probable. Their position is, however, so remarkable, that I was for a long time unable to understand the meaning of them.

"On one side of the specimen there are a small number of the interseptal molds that project beyond the others, and one of these shows one of its lateral faces for a considerable distance lengthwise, and also nearly down to the outer surface of the inner wall. An examination of this face shows that the cavities observed along the furrows extend but a short distance inward, and that the septa arched around the funnel-like projections which they represent from below, striking the outer wall only at the intervening spaces. * * * * * It is further shown that these cavities are directed slightly upward, or toward the aperture of the cup. These characters serve to distinguish the form at once from *Archæocyathellus*, in which the septa meet the outer wall uninterruptedly.

"If I am right in viewing the cavities along the furrows in the cast as indicating the presence of external orifices at these points, then it follows that these orifices were doubtless functionally equivalent to the double row of orifices along the furrows of the outer wall of *Archæocyathellus*. In proof of this it may be remarked that the size of the cavities indicates that the orifices were, proportionally, considerably larger than those of the only known species of *Archæocyathellus* (*A. Rensselaericus*), while their position is such as to present no obstacle in the way of regarding them as having communicated simultaneously with two of the interseptal spaces."

As stated under the generic description, the proposed genus Protocyathus does not appear to be well established. The difference given, the occurrence of a single row of large pores over the septum which is based on the inner cast of the outer wall, is not, so it appears to me, of generic value. The same structure is shown in fig. 2 of pl. v, a specimen that I doubtfully refer to this species in preference to *E. Rensselaericum;* the reason for this is shown by fig. 2, pl. iv, the holes being the openings through the septa connecting the interseptal spaces; the outer wall having been removed in figs. 2, 2*b*, of pl. v. We shall await further evidence before accepting the genus Protocyathus.

Formation and locality.—Middle Cambrian. Conglomerate limestone, on the ridge east of the city of Troy, New York.

Genus LEPTOMITUS n. gen.

Leptos (fine), mitos (thread).

Elongate bodies, formed of fine thread-like longitudinal lines (?) apparently imbedded in a delicate membrane (?), slowly expanding from a narrow base.

The appearance of these bodies is such as might be formed by the tuft of long silicious spicules of the glass-rope sponge, Hyalonema, if the latter were pressed out between the layers of the shale and the animal matter formed a film about the fine, delicate, thread-like spiculæ. In the type specimen a confused mass of spiculæ (?), crossing each other at right angles, occurs at the larger end. Type *Leptomitus Zitteli.*

LEPTOMITUS ZITTELI n. sp.

Plate ii, figs. 2, 2*a*.

Several fragments of this form were found in the fine-grained argillites at Parker's quarry in association with *Olenellus Thompsoni*, *Protocaris Marshi*, &c. The resemblance to a bundle of the elongate spiculæ of Hyalonema is very striking, and the occurrence of the confused and broken spicules at the larger end of the best preserved specimen, and the crossing of the lines or striæ and their breaking up into several parts at the opposite end, give added force to the comparison.

Although we have no proof that the sharp raised lines were slender silicious spicules, there is little doubt in my mind that in this form we have a representative of Hyalonema in the Middle Cambrian.

My first impression was that the species was related to *Serpulites dissolutus* Billings, of the Trenton limestone, but an examination with a magnifying glass at once dispelled the idea and caused a reference to the Spongiæ.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's quarry, Georgia, Franklin County, Vermont.

Genus PROTOSPONGIA Salter.

Protospongia Salter, 1864. Quart. Jour. Geol. Soc., vol. xx, p. 238, pl. xiii.

PROTOSPONGIA FENESTRATA Salter.

Plate vi, figs. 2, 2*a*–*b*.

Protospongia fenestrata Salter, 1864. Quart. Jour. Geol. Soc., vol. xx, p. 238, pl. xiii, fig. 12*a*–*b*. *Ibid.*, Cat. Cambrian and Silurian Fossils, p. 3, 1873.

Hicks, 1874. Quart. Jour. Geol. Soc., vol. xxvii, p. 401, pl. xvi, fig. 20.

Zittel, 1877. Abh. der k. bayer. Akademie der Wiss., 2. Cl., xiii. Bd. "Studien ii. Fossile Spongien" (p. 45, sep. copy).

Carter, 1877. *Ann. and Mag. Nat. Hist., ser. 4, vol. xxv, p. 177.*

Brögger, 1878. Om paradoxidesskifrene ved Krekling. Separataftryk af Nyt Magazin for Naturvidensk., vol. xxiv, i, p. 20, t. 6, f. 14.

Sollas, 1880. Quart. Jour. Geol. Soc., vol. xxxvi, p. 362, figs. 1, 2.

Roemer, 1880. Lethea Geogn., 1. Th., p. 316, f. 59.

Hinde, 1883. Cat. Fossil Sponges, p. 129, pl. xxviii, fig. 2.

Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 11, pl. ix, figs. 5, 5*a*, *b*.

Mr. Salter originally described this interesting sponge as having a loosely reticulate skeleton formed of very large cruciform spiculæ, the branches of which cross each other at an angle of 80°, and only in one plane, no ascending or descending branches rising from the point of conjunction. The angles occasionally vary, but not much.

More perfect specimens obtained by Dr. Hicks show the spiculæ to be quadriradiate, slightly raised at the center, and formed of four nearly cylindrical rays.

The skeleton, as described by Mr. Sollas, is composed of large primary spiculæ, with the interspaces filled in by three series of spiculæ, each formed of spiculæ smaller than those preceding it, their rays all lying regularly disposed in two directions at right angles to each other, and so building up a net-work with square meshes.

The skeleton is not preserved in any of the Nevada specimens, the different sized spiculæ lying scattered on the surface of the limestone shale or crowded together without any regularity in the direction of the rays or the size of the spiculæ. The spiculæ, however, appear to be identical in all respects with those described by Messrs. Salter, Hicks, and Sollas, and if they had not been scattered or crowded together by accident would form a skeleton similar to that described by Mr. Sollas. The under side of the spiculæ shows no trace of a fifth ray or its point of attachment, appearing in this respect like the upper side, except that the surface is a little concave instead of convex on the upper side. They are silicious and differ in mineral character from the spiculæ of the Cambrian rocks of Wales which have been replaced by pyrite.

Dr. Hicks states that *P. fenestrata* occurs in the Longmynd Group, in the Menevian Group, and also in the Upper Lingula flags to the base of the Tremadoc rocks, giving a vertical range of from 8,000 to 10,000 feet (Quart. Jour. Geol. Soc. London, vol. xvii, 1872, p. 181). It also occurs in black shales of Cambrian age in Norway and Sweden.

Mr. G. F. Matthew also notes the presence of the genus in the St. John Group of New Brunswick.

Formation and localities.—Middle Cambrian, Prospect Mountain limestone. In the mountain shale near the Eldorado mine and in the Secret Cañon shale on the east side of Secret Cañon, Eureka District, Nevada.

Genus STREPHOCHETUS Seely.

Strephochetus Seely, 1885. Amer. Jour. Sci., 3d ser., vol. xxx, p. 357.

Original description.—" A free calcareous sponge, showing in structure concentric layers composed of minute twining canals." Under the description of the type species, *S. ocellatus*, the author says: "A compact calcareous sponge, spherical or slightly flattened, distinctly concentric in character, usually less than half an inch in diameter, forming, when in masses, a tough limestone. When weathered the concentric character is very evident, the fossil then looking like little eyes peering from the stone.

"These forms are often gathered in crowded masses, the intermediate spaces being filled with fragments of the fossil mingled with oölitic grains. More rarely they appear here and there in a mass of oölite."

With the exception of the minute twining canals, the above description applies closely to the sponge or Stromatopora-like bodies from the Middle Cambrian of Nevada. The minute structure has been destroyed by crystallization, and the reference to Strephochetus is simply to call attention to the presence of organisms resembling the type species *O. ocellatus* from the Chazy limestone of the Lower Silurian (Ordovician).

STREPHOCHETUS? sp.?

Spherical or oval bodies with a concentric structure, averaging 15^{mm} in diameter and occurring scattered through a compact limestone and an arenaceo-calcareous rock. Minute structure unknown.

Formation and localities.—Middle Cambrian. Calcareous layers in the sandy shales above the quartzite of Prospect Mountain, Eureka District, and at Silver Peak, longitude 117° 20′ west, latitude 38° north, Nevada.

HYDROZOA.

Dr. Emmons described a number of Graptolites from "Taconic" rocks (Amer. Geol., vol. i, pt. 2, pp. 104–110), but, when we come to study them and also the author's remarks on their stratigraphic position, we are compelled to reject all but two species from the Georgia Formation or Middle Cambrian; these we found in the argillaceous shales at Parker's quarry, Georgia, Vermont.

In a letter written to Prof. Jules Marcou, December 28, 1860, Mr. Emmons states "that most if not all those beautiful graptolites referred to the Hudson River Group by Prof. T. Hall belong to the Taconic. There are probably two species in the Trenton and the slates above. No more." (Proc. Amer. Acad. Arts and Sci., new ser., vol. xii, 1885, p. 188.) This proves that Mr. Emmons had not a clear idea of the position of the shales of the Hudson River Valley that contain the graptolites described by Prof. Hall, nor of the shales at Point Levis carrying the graptolitic fauna. Elsewhere in Vermont, Virginia, and Tennessee he did not distinguish between the older rocks and those of the Hudson River Formation. Of this we will speak at another place and time.

Prof. Hall described *Graptolithus Milesi* (Geology of Vermont, vol. i, 1861, p. 372) as from a bowlder of Georgia slate picked up in the town of Monkton, Vermont. The species is of the type of those from Point Levis, and as nothing of the kind has yet been found in situ in the Georgia shales, and the bowlder was found on the line of the glacial drift from Canada, I do not think it best under the circumstances to admit the species to the Georgia fauna. Prof. Hall thinks that "it is probably of the Quebec Group." (Can. Org. Remains, Dec. II, p. 53.)

On plate i of his American Geology, Prof. Emmons figures two species of graptolites, fig. 11 as *Diplograptus secalinus* and fig. 2 as an undetermined species.

At Swanton Falls, Vermont, a species of graptolite occurs in the shales that is identical with *Climacograptus bicornis* of the Hudson River Formation. Prof. Marcou refers the strata containing the graptolites to the Taconic, and places it below the Potsdam sandstone, but I think without either stratigraphic or paleontologic evidence.

Genus DIPLOGRAPTUS McCoy.

DIPLOGRAPTUS ? SIMPLEX Emmons.

Plate xi, figs. 4, 4*a*.

Diplograptus simplex Emmons, 1855. Amer. Geol., vol. i, pt. 2, p. 104, pl. i, fig. 11.

Original description.—" Straight; serrations pointed, cells, rather distant oblique to the axis; the serration equal in length to one-sixth or one-seventh of the width of the stem. The upper or young part of the stem is three-eighths of an inch wide and the number of serrations is 24 to an inch. It narrows towards the base, where the serrations are rather obtuse and more distant than those above, and is 10 inches long as exposed upon the slate. It is confined to the Hoosic roofing slate."

Dr. Emmons originally applied the name *Fucoides simplex* (Taconic System, 1844, pl. v, fig. 1; Agric. Rept. N. Y., pt. 5, 1846, pl. xvii, fig. 1) to a species previously named by Prof. Amos Eaton (see Twentieth Rept. N. Y. State Mus. Nat. Hist., 1868, p. 268) as *Fucoides secalinus*. Subsequently he referred the species named by him to Eaton's *F. secalinus*, calling it *Diplograptus secalinus*, gave a description as above, and at the same time figured another species which we have found in the fine argillaceous shales of Parker's ledge. For this I have decided to use Emmons's name *simplex*, the name *D. secalinus* being restricted to the species from the Hudson River Group, as described by Prof. Hall (Pal. N. Y., vol. i, 1847, p. 267).

The specimens from Vermont are completely flattened in the shale, and are small as compared with the stipes described by Dr. Emmons, as the largest one is scarcely 2 inches in length and the small ones have much the same appearance as the compressed frond of a Phyllograptus, but the similarity between the figure given in his American Geology and the central portion of the longer fronds from Vermont is so marked that I think they are identical. Dr. Emmons states that the known locality was in the Hoosic slate, but I suspect, from his having worked to the north in Washington County, New York, he may have procured the specimen figured from some other place, referring the slate to the same geologic age as that at Hoosic; this is the more probable, as a similar confusion of localities is to be detected in other parts of his work. The details of the description are drawn apparently from the small specimen figured, rather than from the distorted specimens usually observed in the Hoosic slate. In several of the Vermont specimens there is a strong, round, central axis, as shown in fig. 4 of plate xi, that appears as though a hollow axis had been filled with sediment in a more or less complete manner, thus preserving the form of the axis, while in other specimens it was compressed and all traces of it lost.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's quarry, Georgia, Franklin County, Vermont.

Genus CLIMACOGRAPTUS Hall.

CLIMACOGRAPTUS ? ? EMMONSI n. sp.

Plate xi, fig. 5.

The only specimen we have of this species is the upper portion of a single stipe found by Mr. E. Hurlburt in the same band of shale with *Diplograptus ? simplex*, *Mesonacis Vermontana*, *Olenellus Thompsoni*, and *Protocaris Marshi*.

The stipe is elongate, narrow, and with narrow, deep indentations on each side, at right angles to the axis of the stipe, that reach well in towards the center, leaving short, strong pinnula-like projections between them that alternate, with relation to each other, on the opposite sides of the stipe. Where the stipe is 4^{mm} broad, ten indentations occur in a distance of 11^{mm}. The position and character of the cellules are unknown; whether they are in the deep indentations, and the specimen shows the lateral view of a compressed stipe, as in Climacograptus when similarly compressed, or whether they form the rather large projecting points between the indentations, somewhat as in Rastrites, is not determined. The reference to Climacograptus is entirely provisional, and not intended to indicate the presence of that genus in the Georgia Formation, but that a form too imperfect for a close generic reference, resembling compressed specimens of Climacograptus, occurs at that horizon.

Sooner or later more extensive collections will be made in the Georgia shales, and it may be that the graptolitic fauna will be more fully developed.

The specimen figured by Dr. Emmons as "intermediate species" (Amer. Geol., pl. i, fig. 2) appears to be the same as the specimen under consideration. No description or reference to locality is given by Dr. Emmons.

The specific name is given in memory of Dr. E. Emmons, who struggled so long to maintain the pre-Potsdam age of the formation in which this graptolite occurs.

For the use of the specimen I am indebted to Mr. E. Hurlburt, of Utica, New York.

Formation and locality.—Middle Cambrian, Georgia formation. Parker's quarry, Franklin County, Vermont.

ECHINODERMATA.

Genus EOCYSTITES Billings.

Eocystites Billings, 1868. Acadian Geology, p. 643, fig. 220.

EOCYSTITES ?? LONGIDACTYLUS n. sp.

Plate v, fig. 3; pl. vi, figs. 1, 1*a–c*.

General form elongate-oval or ovate, as far as can be determined from the crushed specimens. Plates numerous, disposed without apparent order and varying in form, size, and surface characters on the same body. The margin of many of the plates appears to be indented so as to leave an opening, or pore, that passed into the central cavity; these plates are grouped together on one side, so far as we now know. The surface of the plates varies: (1) smooth and nearly flat; (2) smooth and slightly elevated at the center; (3) smooth and depressed at the center, with more or less distinct ridges radiating out to the margin; (4) more or less prominent ridges radiating out from the center to the margin. The plates of type 4 have crenulations on the margin that give rise to an appearance of the presence of pores. None of the openings of the body has yet been observed.

A row of long slender arms appears to have surrounded the summit. Unfortunately our specimens do not show the summit distinctly, nor the arrangement of the arms about it, although, in the specimens represented by figure 1*b*, the bases of several arms are present on what appears to be the inner side of the summit of the body. The arms are formed of two series of plates that slightly alternate in relation to each other, as shown in fig. 1*b*. Casts of short pinnulæ are seen along the side of several of the arms—a pinnule to each plate on the side at which it occurs. None of the arms show an ambulacral groove. Stem or pedicle unknown.

The specimens collected are from a pinkish argillaceous shale and have been injured by distortion and compression. Plates of the same general type were found 1,000 feet lower in the strata in the Ely Mountains associated with *Olenellus Gilberti;* also, at Parker's quarry, Georgia, Vt., associated with *Olenellus Thompsoni*, *Olenoides Marcoui*, *Protypus senectus*, &c.

The reference of this species to the genus Eocystites is entirely provisional, as the genus was founded on loose plates of a cystid found in the St. John Formation of the Lower Cambrian System. The St. John Formation plates are more strongly ridged than those of *E.? ? longidactylus*, but I know no way of generically distinguishing them, or either of these, from the plates described as *Protocystites Menevensis* Hicks (Quart. Jour. Geol. Soc., vol. xxviii, p. 180, pl. v, fig. 19). Under the circumstances I prefer to wait until more is known of the described genera before definitely expressing an opinion on the generic relations of *P. ? ? longidactylus.*

Trochocystites Bohemicus Barrande (Bull. Soc. Géol. de France, 2e sér., t. xvii, p. 537, pl. viii, fig. 1) appears to be distinct from both Eocystites and Protocystites.

Formation and localities.—Middle Cambrian. Chisholm mine, southwest slope of the Ely Mountains near Pioche; also, in the Highland range, eleven miles north of Bennet's Spring, Nevada, associated with *Olenoides typicalis*, *Bathyuriscus producta*, *Ptychoparia Piochensis*, &c.

BRACHIOPODA.

Genus LINGULELLA Salter.

Lingulella Salter, 1861. Memoirs Geol. Surv. Gt. Brit., p. 333.

LINGULELLA CÆLATA Hall (sp.).

Plate vii, figs. 1, 1*a*–*d*.

Orbicula cælata Hall, 1847. Pal. N. Y., vol. i, p. 290, pl. lxxix, figs. 9*a*–*c*.
Obolella (*O.*) *cælata* Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33.
Lingulella cælata Ford, 1878. Amer. Jour. Sci., 3d ser., vol. xv, p. 127.

Original description.—"Orbicular, small; apex excentric, depressed along the center, and subplicated near the margins; surface marked by fine concentric lines and minute elevated points, giving it the appearance of being covered by a poriferous coral."

Mr. Ford subsequently studied the species and described it as follows: "The ventral valve is somewhat elongate-ovate, with the beak pointed, slightly elevated, and conspicuously channeled for the passage of the pedicle. The convexity is moderate and nearly uniform. On the inside there are two prominent, elongate, curved scars, one on either side of the median line, with their concavities directed outward. These recall by their form and position the large lateral scars of the ventral valve of certain species of *Obolella* (e. g., *O. chromatica*). The other impressions of this valve have not been made out.

"The dorsal valve is more rotund than the ventral and has the beak much depressed. The convexity increases with increasing age, and in adult specimens is such as to sometimes give the valve a semi-globose appearance. A shallow depression extends in all the specimens from the beak to the front margin, but in fully grown forms it is often inconspicuous. On the inside there are four prominent ridges. Of these the more central two commence close to the median line a short distance in front of the beak and extend into the forward third of the shell slightly diverging throughout, while the lateral pair take their rise close to the beak and reach to points a little in advance of the mid-length. There is also a short, slender ridge directly beneath the beak, on the median line. The central portion of the valve in the upper half is slightly excavated. The description of the interior of this valve has been mainly drawn up from an excellent natural internal mold.

"The surface of both valves is ornamented with moderately conspicuous radiating and concentric lines, the latter irregularly grouped, and covering the whole a fine papillose network, the points of which are arranged in concentric series, those of one series alternating with those of the next, and so on, as first pointed out by Professor Hall in his description of the dorsal valve. (Pal. N. Y., vol. i, p. 290, pl. 79, fig. 9.) The effect of this style of ornamentation is very beautiful, and when, as is usually the case, the shells have a dark, polished aspect, with a setting of light-colored limestone, few handsomer fossil objects can be named. The shell is thick and of a finely lamellar structure. The usual length of the ventral valve is about three and one-half lines."

To Mr. Ford's description we may add that the interior of the shell shows rather large punctæ or small pits, as in the type of the genus *Lingulella Davisii*. There is also considerable variation in the strength and character of the papillose surface. In some small shells it is very difficult to detect it at all, and in others the arrangement of the papillæ is so broken by the fine, wavy concentric lines and stronger, radiating, undulating lines that the surface appears more like that of some species of the genus Kutorgina than that of the typical species of Lingulella.

Formation and locality.—Middle Cambrian, Georgia Formation. Conglomerate limestone on the ridge east of the city of Troy, N. Y.; also, one mile south of Schodack Landing, in Columbia County, New York.

LINGULELLA ELLA H. & W.

Plate vii, fig. 2; pl. viii, fig. 4, 4*a–e*.

Lingulepis Ella Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 232, pl. i, fig. 8.

Original description.—"Shell below the medium size. Dorsal valve subcircular or oblate, the width slightly exceeding the length; the beak perceptibly projecting beyond the general contour of the shell, but very obtuse and slightly truncate; sides and base rounded, the latter more broadly curved. Surface of the valve depressed-convex, a little the most prominent on the umbone; marked by fine, irregular, concentric lines of growth on the upper part, becoming more strongly marked and finally quite lamellose toward the margin of the valve. A few very indistinct, radiating lines may be seen near the beak by the aid of a strong magnifier. Ventral valve unknown. Shell-substance phosphatic.

"There may be some doubt as to the true relations of this shell. The broadly oblate form would be an objection to considering it as a true *Lingula*, while the truncation of the beak of the dorsal valve would accord more nearly with what is known of some forms of *Lingulepis*. It is possible it may prove to be *Lingulella*, but in the absence of the ventral valve it cannot be satisfactorily determined. It differs from most known species very perceptibly in the oblate form of the valve.

"*Formation and locality.*—In greenish argillaceous shales of the age of the Quebec group, in the cañon above Call's Fort, north of Box Elder Cañon, Wasatch Range, Utah. Collected by S. F. Emmons, esq."

The reference of the species to the Quebec Formation is incorrect, as it occurs with a characteristic Middle Cambrian fauna, 2,000 feet below the Potsdam horizon of the Upper Cambrian.

More perfect specimens of the dorsal valve show the surface characters, and also show that the beak is slightly more projecting.

The ventral valve is longer than wide; angle formed by the cardinal slopes about 65° in uncompressed specimens and 90° to 120° in flattened, compressed specimens; sides arching to the broadly rounded frontal margin; area flattened, rather broad, and with a narrow median groove. The cast of an interior of a dorsal? valve from the Oquirrh Range shows two long lateral scars gradually diverging from near the beak, also a central median depression with two posterior adductor scars, and the anterior adductor scars near the terminus. The system of scars, so far as preserved, is much like the dorsal valve of *Obolella crassa*. (See pl. x, fig. 1*e*. Compare also with Lingula, Monographs United States Geological Survey, vol. viii, plate xxi, figs. 18–20.)

Surface marked by fine concentric lines of growth, and on some shells fine radiating lines are seen near the beak; when the surface is entire a secondary system of ornamentation is seen as very fine concentric striæ, broken by very short undulations that give almost a reticulated surface.

The Wasatch specimens show valves 2mm to 9mm in length. Those from near Pioche are more compressed and appear more quadrangular and broader than the Wasatch forms, except in the small shells, which are very much alike. When the dorsal valves are compressed longitudinally, the cardinal line is straightened and the concentric striæ are depressed, so that the shell might readily be taken for a species of Kutorgina.

Figures 4*b* and 4*c*, pl. viii, are drawn from casts of the interior of the two valves as they occur in the shales of the Highland Range and at the Chisholm mine, near Pioche. Figure 4*d* shows the relative proportions of the valves to each other when flattened in the shale.

Formation and localities.—Middle Cambrian. Box Elder Cañon, above Call's Fort; Big Cottonwood Cañon, one mile below Argenta, Wasatch Mountains; East Cañon, above Ophir City, Oquirrh Mountains, Utah, in dark silicious argillites; also, in the pinkish argillaceous shale at the Chisholm mine, southwest face of the Ely Mountains, near Pioche, Nevada.

Genus ACROTRETA Kutorga.

Acrotreta Kutorga, 1848. Verhandl. der russisch. kais. min. Gesellsch., St. Petersburg, 1847, p. 275. Type *A. subconica*, same report, p. 275, pl. vii, figs. 7*a–c*.

ACROTRETA GEMMA Billings.

Plate viii, figs. 1, 1*a*, *b*.

Acrotreta gemma Billings, 1865. Paleozoic fossils, vol. i, p. 216, figs. 201*a–f*.

Acrotreta subconica and *A. Attenuata* Meek, 1873. Sixth Ann. Rep. U. S. Geol. Surv. Terr., p. 463.

Acrotreta pyxidicula White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid., Rep. Invert. Foss., p. 9; vol. iv, pt. 1, p. 53, pl. iii, figs. 3*a–d*, 1875.

Acrotreta gemma Walcott, 1884. Mongraphs U. S. Geol. Survey, vol. viii, Pal. Eureka district, p. 17, pl. i, figs. 1*a*, 1*b*, 1*d*, 1*f*; pl. ix, figs. 9, 9*a*.

Original description.—"Shell very small, about 1 line in diameter; one valve nearly flat and the other acutely conical. Dorsal valve very gently convex, nearly circular; sides and front margin uniformly rounded; posterior margin very obtusely angulated at the beak, on each side of which a portion of the cardinal edge, equal to one-fourth of the whole width of the shell, is nearly straight; umbo very small; beak apparently depressed to the hinge line and not projecting beyond it; cardinal angles compressed, broadly rounded; a wide, shallow, mesial sinus extends from the front margin about half way to the beak; elsewhere the valve is gently convex or nearly flat.

"Ventral valve acutely conical, with a flat triangular area which is perpendicular to the plane of the lateral margin, its base half the width of the whole shell. In the apex of this valve there is a minute circular aperture, and in one specimen a dark line extends from it down the middle of the area, which appears to represent the foraminal groove of this genus; but in two other specimens of the ventral valve, with the area well preserved, there is no indication of a groove. Surface with very fine concentric striæ.

"Width of dorsal valve, about one line: length, about eight-ninths of a line. The height of the ventral valve is about one line.

"The form of this species is very like that of *A. subconica* (Kutorga), but that species is twice the size of this and has the area distinctly grooved."

The groove on the area, of which Mr. Billings speaks, is variable; in some specimens it can be scarcely determined and in others it is quite distinct. As far as the size is concerned, we have specimens from 2^{mm} in diameter up to 5^{mm}. The variation in the height of the ventral valve is also considerable.

The relations of the species to *Acrotreta subconica* Kutorga (Über die Brachiopoden-Familie der Siphonotretææ. Verhandl. der russisch. kais. min. Gesellschaft, 1848, p. 275, pl. vii, figs. 7*a*–*c*) are strong, and, except the greater elevation of the ventral valve, there are no marked differences. Without a direct comparison of specimens, I do not think it best to identify the American form with the Russian, although, from its having such a great geologic range, it was probably widely distributed in the Cambrian seas.

In the Paleontology of the Eureka District, pages 17 and 18, I have given the range of this species as then known. We now have to add that it occurs at a horizon 4,000 feet below the lowest horizon there and is associated with species of Olenellus just above the great series of Cambrian quartzites. The shell is more robust and larger than the average specimens of the Upper Cambrian, but specimens from the Upper Cambrian beds on the Gallatin River are nearly as large, and the form of the exterior of the valves and their interior muscular markings are essentially the same; the differences are so slight that I do not hesitate to place them under one species. More favorable conditions of habitat and food would produce the variation in size; also, the change liable to occur in a species living through so long a period of time as the accumulation of 3,000 feet of limestone would require.

The associated species are *Kutorgina pannula*, *Acrothele subsidua*, *Orthisina* sp.?, and trilobitic remains.

Formation and locality.—Middle Cambrian. East side of anticlinal, in limestone just above quartzite, Pioche, Nevada.

Genus IPHIDEA Billings.

Iphidea Billings, 1874. Can. Nat., new ser., vol. vi, p. 477.

IPHIDEA BELLA Billings.

Plate vii, fig. 4.

Iphidea bella Billings, 1872. Can. Nat., new ser., vol. vi, p. 477. *Idem*, 1874. Pal. Foss. vol. ii, pt. 1, p. 76.

The descriptions of the genus Iphidea and the type species *I. bella* were united in the following:

Original description.—" Of this genus we have no specimens showing the internal structure, but the external characters seem sufficient to separate it from any described generic group. The ventral ? valve of *I. bella* is conical, strongly elevated at the beak, hinge-line nearly straight, posterior angles narrowly rounded, sides and front nearly uniformly rounded, forming rather more than a semicircle. Posterior side with a large false area and a convex pseudo-deltidium, the width of which at the hinge-line is nearly one-third the whole width of the shell. The dorsal valve is semicircular, moderately convex, most elevated at the beak. The hinge-line appears to be straight. The form and structure of the posterior side (such as the area, foramen, deltidium, &c.) cannot be made out from the specimen, owing to its imperfection. The surface is covered with fine concentric striæ, which in the ventral ? valve are continued around on the area. Of these striæ there appear to be from fifteen to twenty in the width of one line, their size varying somewhat in different parts of the specimen. There are also a few obscure radiating striæ. Width of ventral valve, seven lines; length, five lines; height, two lines.

" In the specimen above figured there is an aperture in the beak, but in another there is no appearance whatever of a perforation. This genus resembles *Acrotreta*, but differs therefrom in having a large convex deltidium. It seems to be also closely allied to *Kutorgina*. The shell which I have described under the name of *Obolus Labradoricus* belongs to this genus.

"*I. bella* was found by T. G. Weston, in a bowlder of limestone associated with numerous fragmentary trilobites, of primordial age, near Trois Pistoles, below Quebec. A closely-allied species of the same genus occurs in the primordial limestone at Topsail Head, Conception Bay, Newfoundland."

As will be seen by my refeience of *Obolus Labradoricus* to Kutorgina, I do not agree with Mr. Billings in his reference of that species to iphidea. There does not appear to be much resemblance between the two when a series of the specimens are compared.

When studying the brachiopoda of the Upper Cambrian (Potsdam) horizon the genus will be more fully described, as we have very perfect specimens of a species from the Tonto formation of Arizona that appear to be identical with *Iphidea ornatella*, described by Dr. G. Linnarsson, from the Cambrian of Sweden.

Formation and localities.—Middle Cambrian. Besides the localities mentioned above, *Iphidea bella* occurs in the limestone of L'Anse au Loup, on the straits of Belle Isle, but its presence in Vermont, New York, or Nevada has not yet been recorded to my knowledge.

Genus KUTORGINA Billings.

Kutorgina Billings, 1861. Pamphlet; and Geology of Vermont, vol. ii, p. 948, foot-note. *Idem*, 1865. Pal. Foss., vol. i, p. 9.
Kutorgina Davidson, 1871. Mon. Brit. Foss. Brach., vol. iii, p. 342.

Mr. Billings proposed the genus Kutorgina in a foot-note accompanying the description of the type species *K. cingulata*. He says: "Since the above was written I have examined many casts of the interior of this species, and am inclined to the opinion that it is generically distinct from *Obolella chromatica*. From the very considerable elevation of the beak the dorsal valve must have an area and probably a foramen. In one specimen there are two large oval impressions faintly impressed, but still distinctly visible. There is no trace of the lateral scars; and the form, notwithstanding the characters of the surface, conveys the idea of an *Orthisina*. Should, upon further examination, my suspicions turn out to be well founded, I shall call the genus KUTORGINA, after the celebrated European naturalist, Kutorga."

The species now referred to the genus are:

Kutorgina sculptilis Meek,
Whitfieldi Walcott, } Upper Cambrian.

cingulata Billings,
Labradorica Billings,
pannula White,
Prospectensis Walcott, } Middle Cambrian.

From the character presented by these the following generic diagnosis is drawn:

Shell inequivalve, transverse, or elongated; hinge-line extended nearly to the width of the shell.

Larger or ventral valve convex, elevated at the beak, which is straight or incurved, with or without a mesial sinus; area narrow, or without a true area; when present it is divided by a wide, open fissure. Smaller or dorsal valve flat or slightly convex, beak marginal.

The areas of both the ventral and the dorsal valves of the species which we have showing them are very narrow and the fissure between them broad and relatively large. A number of thin longitudinal sections, cut so as to cross the beak and also out on the cardinal edges, fail to show any covering to the fissure, and the area appears to be little more than the reflexed shell, as the lines of growth of the valve extend over and upon it.

Exterior of valves marked by concentric striæ or lines of growth that terminate on the cardinal edges of the valves, as in *K. cingulata*; nearly smooth and shiny, as in *K. Labradorica;* like that of *Trematis*, *K. pannula*, or Lingulella, *K. sculptilis*.

The interiors of the valves of the only species that we have showing the interiors, *K. cingulata*, have numerous radiating striæ extending from the beak outward toward the margins of the shell.

In the interior of the ventral valve four pairs of scars extend from the beak forward, as shown in fig. 1*d*, pl. ix.

The interior of the dorsal valve is divided midway by a narrow mesial ridge that separates two pairs of scars (adductors?); the anterior pair small.

Shell structure calcareous (*K. cingulata*, *K. Whitfieldi*), or horny (*K. Labradorica*, *K. sculptilis*).

KUTORGINA CINGULATA Billings.

Plate ix, figs. 1, 1*a*-*h*.

Obolella cingulata Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 948, figs. 347 and 349. *Idem*, 1863. Geol. Canada, p. 284, figs. 287*a*, *b*.

Obolella (Kutorgina) cingulata Billings, 1865. Pal. Foss., vol. i, p. 8, figs. 8, 10.

Obolella (?) *Phillipsi* Davidson, 1866. Mon. Brit. Foss. Brach., vol. iii, p. 62, pl. iv, figs. 17–19.

Kutorgina cingulata Davidson, 1868. Quart. Jour. Geol. Soc., vol. v, p. 312. *Idem*. 1871. Mon. Brit. Foss. Brach., vol. iii, p. 342, pl. 4, fig. 25.

Kutorgina cingulata var. *pusilla*, Linnarsson, 1876. Brach. Par. Beds of Sweden. Bihang till k. Svensk. Vet.-Akad. Handl. Band 3, N:o 12, p. 25, pl. iv, figs. 53, 54.

Original description.—"Hinge-line straight, a little less than the greatest width of the shell; sides straight or slightly convex for about one-half the length; anterior angles obtusely rounded, front margin either uniformly convex or with a small portion in the middle somewhat straight. Greatest width a little in front of the middle. Ventral valve strongly and uniformly convex, most tumid about the middle; beak depressed below the greatest convexity of the shell; cardinal edges straight or gently concave, diverging from the beak at an obtuse angle; area unknown. Dorsal valve somewhat flat, most elevated at the beak, in front of which, along the middle of the shell, there is a wide, shallow concavity extending to the front margin; on each side of the beak, descending with a somewhat flat slope to the cardinal angles; area unknown, apparently half the height of the ventral area and nearly at right angles to the plane of the margin. Beak erect, obtusely pointed, forming the most elevated part of the shell. Surface with strong concentric sublamellose ridges, which do not converge to the beak, but terminate on the cardinal edges, their course conforming to the margin of the shell. Four or five ridges in the width of one line.

"Length of largest dorsal valve seen, six and one-half lines; greatest width, eight lines. Length of largest ventral valve in a straight line from beak to front, seven lines; width, ten lines. The proportional length and width appear to vary. The apical angle of the ventral valve also varies, being in some specimens much more pointed at the beak than in the one above figured. Specimens of all sizes occur from three lines in width upward."

Having obtained a large series of specimens from east of Swanton, Vermont, the following observations are added to the above description:

Shell transversely to longitudinally oval; more or less plano-convex; cardinal angles about 100°; hinge-line a trifle less than the greatest width of the shell. Ventral valve convex; arching gently from the frontal margin to the deepest part of the valve, it curves more abruptly over to the slightly incurved, pointed beak; a mesial sinus of varying strength occurs on many shells and in others it is entirely absent; a false area without a trace of an opening extends some distance beneath the beak and out to the extremity of the hinge-line, where it narrows to a little more than an inflected cardinal margin. Dorsal valve transverse, depressed, rising to the highest point at the beak, which is elevated, but not incurved, over the hinge-line; in some examples the valve is unusually flat, with a low, round, pointed beak rising at the center of the cardinal line; in others the beak is more elevated, the body of the valve sloping up towards it. Shell structure calcareous. Surface marked by concentric striæ and undulations of growth that give the older shells a rough appearance.

The muscular impressions of the ventral valve are preserved as dark, narrow, elongate scars, two each side of the median line and two near the lateral margins; the central pair (fig. 1, pl. ix) appear to diverge from a single scar extending forward from near the beak; the next pair are broader and longer and much like the two lateral pairs. Numerous striæ, about .5^{mm} apart, radiate from the vicinity of the beak forward and laterally to the margins of the shell.

The scars of the interior of the dorsal valve are better preserved than those of the ventral; a short, central, elevated line extends about halfway from the beak to the front margin, separating two large posterior and two small anterior (adductor?) scars; the posterior scars have a low ridge bounding them, outside of which numerous strong lateral sinuses radiate out a short distance; the radiating lines observed on the cast of the ventral valve also occur on casts of the dorsal valve. I am not sure but that Mr. Billings's fig. 348 (Geol. Vermont, vol. ii, p. 948) is similar to the compressed specimens of the ventral valve from Parker's quarry. Figures 1*g*, 1*h*, plate ix, are taken from two compressed ventral valves from the arenaceo-argillaceous shales at the Parker quarry. But for the fact that we have specimens showing forms between figures 1*a*, 1*b*, and 1*g*, 1*h*, the tendency would be to separate the latter as a distinct species, as the outline of the valve is lost and the surface characters are largely obliterated.

The scars of the ventral valve appear much like those of the ventral valve of *Lingula Feistmanteli* Barrande (Syst. Sil. de Bohême, vol. v, pl. 106, III, 1A), and what is seen of the muscular impressions of the dorsal valve recalls the adductor scar of the Lingulidæ more than those of the Obolidæ. Until more is known of the interior of the valves it is hazardous to make comparisons, for, in the case of the Lingula figured by Barrande, he found later, and figured on plate 110, quite a change in the scars as compared with those shown on plate 106.

In Sweden, *K. cingulata* is associated with *Paradoxides Forchammeri* and *Agnostus lævigatus*. The English specimens are found in the Middle and Upper Lingula flags and Lower Tremadoc. In America, as far as known, it is confined to the Middle Cambrian or Olenellus zone.

Kutorgina Prospectensis differs from *K. cingulata* in having regularly-rounded surface striæ, and also in the more narrow form of the valves.

Formation and localities.—Middle Cambrian, Georgia Formation. Mr. Billings described the species from L'Anse au Loup, Labrador. It is abundant in the lenticular mass of limestone intercalated in argillaceous shales carrying *Olenellus Thompsoni*, on the Bullard farm, about two miles east of Swanton, Vermont. In the form of compressed casts it occurs at Parker's quarry, town of Georgia, Vermont. It is also identified from the Malvern Hills of England, the island of Bornholm, and from Sweden.

This, or a closely allied species, occurs at the same geologic horizon, on Silver Peak, Western Nevada, longitude 117° 20′ W., latitude 38° N.

KUTORGINA LABRADORICA Billings (sp.).

Plate ix, figs. 2, 2*a*, *b*.

Obolus Labradoricus Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 946, fig. 345. *Idem*, 1863. Geol. Canada, p. 248, fig. 291. *Idem*, 1865. Pal. Foss., vol. i, p. 6, fig. 6.

Original description.—"Dorsal valve subcircular, the hinge-line straight and equal to about three-fourths the width of the shell; rather strongly and uniformly convex, most prominent at one-fourth the length from the beak, the latter small, neatly pointed, scarcely distinct from the cardinal edge. Surface with fine concentric striæ, which converge slightly on approaching the cardinal edge, 15 to 20 in one line, and also with a few coarser concentric undulations of growth, the whole crossed by minute radiating striæ just visible to the naked eye. The shell is black and friable like that of a *Lingula*. Length, 5½ lines; width, about 6 lines.

"Ventral valve unknown."

This species occurs in great abundance, associated with *K. cingulata*, in a hard gray limestone east of Swanton, Vermont.

I add to the original description the following:

The ventral valve elevated, with the apex rising slightly above the plane of the large triangular area; the surface of the area is unknown, except a narrow reflected margin.

The dorsal valve is slightly elevated at the beak, more transverse than the ventral, and with a narrower area.

Surface similar to that described by Mr. Billings.

Unfortunately none of the specimens shows the two valves united and the areas of the valves are not preserved. From their non-preservation in this species and also in all the known species of the genus the presumption is that the greater portion of the area was open or else covered by a thin film of shell that is not preserved. There is considerable variation in the relative length and breadth of different shells and in the height of the ventral valve.

An examination of the type specimen of *Obolus Labradoricus*, in the collection of the Geological Survey of Canada, led to the identification of the Vermont specimens as the same species and the generic reference was changed to Kutorgina.

Formation and localities.—Middle Cambrian, Georgia Formation. In a lenticular mass of limestone intercalated in argillaceous shales carrying *Olenellus Thompsoni*, on the Bullard farm, about two miles east of Swanton; also, about two miles east of Highgate Springs, Franklin County, Vermont, and Mr. Billings describes it from limestone at L'Anse au Loup, Labrador.

KUTORGINA PANNULA White. (sp.)

Plate vii, figs. 3, 3*a*, pl. viii, figs. 2, 2*a–c*.

Trematis? pannulus White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid.; Prelim. Rep. Invert. Foss., p. 6. *Idem*, 1875. Same report, vol. iv, pt. 1, 36, pl. i, figs. 4*a*, *b*.

Original description.—"Associated with *Olenellus Gilberti* Meek, a single imperfect specimen of Trematis has been discovered, which, although consisting only of a single valve, possesses such characteristic surface-markings as to indicate its specific separation from all other known forms of the genus.

"The diameter of the specimen is about three millimeters; outline apparently subcircular or a little broader than long; apex moderately prominent and situated near the posterior margin. Surface marked by a very fine net-work of oblique raised lines, dividing it up into minute, four-sided, pore-like pits, which cause it to resemble, under the lens, the texture of finely-woven cloth.

"In the character of its surface-markings this species is nearly related to *T. punctata* Sowerby, sp., as figured by Davidson in his Monograph of British Fossil Brachiopoda, part vii, No. 1. That species, however, reaches a much larger size than our shell, and the small pits that similarly mark its surface are six-sided, instead of four-sided as in ours. The surface of *T. siluriana* Davidson, another allied species, has the pits arranged in radiating instead of oblique lines."

The type specimen is a fragment apparently of the ventral valve. The author's generic reference depended entirely upon the surface characters and was necessarily provisional. I know of another species with a nearly similar surface, from the Tonto Group (= Potsdam) of Arizona. The type is not otherwise known from the Cambrian System, to my knowledge.

The writer in 1885 visited the locality from which the type specimen was collected and found a number of well-preserved ventral and dorsal valves. The ventral valve is elevated at the beak and projects back over the area, which is divided by a broad fissure; the area is a little more than the reflexed margin of the shell. Dorsal valve depressed; beak marginal on a nearly straight hinge line.

As stated by its author, the surface of this shell is similar to that of several species of Trematis. It cannot now be referred to that genus, as the form of the valves is that of Kutorgina. We now have species of Kutorgina with surface characters like those of Lingula, *K. Labradorica;* of Lingulella, *K. sculptilis;* of Trematis, *K. pannula;* of Obolella, *K. cingulata.*

Formation and locality.—Middle Cambrian. Pioche, Nevada, one mile below Argenta, in Big Cottonwood Cañon, Wasatch Mountains, Utah.

KUTORGINA PROSPECTENSIS Walcott.

Plate ix, figs. 3, 3*a*.

Kutorgina Prospectensis Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, Pal. Eureka District, p. 19, pl. ix, figs. 1, 1*a*, *b*.

Original description.—"Shell rather small for a species of the genus. It is thick and black, like a linguloid shell.

"Ventral valve elevated, with the apex projecting over the triangular area and extending considerably beyond the posterior margin. Owing to the exfoliation of the shell the extremity of the apex is unknown; the surface of the area is also unknown. Ventral valve depressed, slightly convex, without a mesial sinus; marginal outline subcircular, with the posterior margin obtusely angular at the beak; the beak is slightly depressed below the highest point of the shell, and apparently projects a trifle beyond the cardinal edge. Surface marked by strongly-defined, fine concentric striæ, ten in a distance of one millimeter, where they terminate on the posterior margin.

"The dorsal valve of this species is much like that of *Iphidea Labradoricus* Billings, but does not appear to come within the limits of that genus as defined by the type species."

A few more specimens have been collected since the original description was written, but none of them shows the interior of either valve or other characters not shown in the types. The strong, concentric striæ and thick shell separate the species from all others of the genus known to me except *K. cingulata*, from which it differs in having a regularly convex dorsal valve, and the surface covered with more uniform, equidistant, concentric striæ.

Formation and locality.—Middle Cambrian. In an arenaceous shale resting on the Prospect Mountain quartzite, summit of Prospect Mountain, Eureka District, Nevada.

The associated fossils are *Olenellus Howelli*, *O. Gilberti*, *O. Iddingsi*, and *Anomocare ? parvum*.

Genus ACROTHELE Linnarsson.

Acrothele Linnarsson, 1876. Brach. Par. Beds of Sweden, Bihang tillte k. Svensk. Vet.-Akad. Handl. Bd. 3, N:o 12, p. 20.

Original description.—"Shell corneous, composed of several laminæ, the inner smooth and polished, the outermost one rough and opaque. Ventral valve slightly conical, with excentric umbone, pierced by a minute foramen, in front of which there are, at least in one species, two small wart-like protuberances; the field between the umbone and the posterior margin is usually a little flattened, thus forming a slight indication of a false area. Dorsal valve with marginal umbone, consisting of two wart like protuberances. In the interior of the dorsal valve there are two oblong, diverging muscular scars close to the posterior margin, and two small, rounded scars near the middle. The muscular scars are separated by a longitudinal ridge."

Mr. Linnarsson considered Obolella and Acrotreta as probably the most nearly related genera to Acrothele.

From our present knowledge of the genus Obolella I think it best not to group Acrothele with it. The genera Acrothele, Schizambon (Monographs United States Geological Survey, vol. viii, p. 69), Acrotreta have a perforated ventral valve that is more elevated than the dorsal. The muscular impressions vary materially, but not sufficiently to prevent the genera mentioned from being grouped together. The genus Linnarssonia has a perforate ventral valve, but it differs in the structure of the shell and the character of the muscular impressions.

The species now referred to the genus are:

Acrothele coriacea Linnarsson.
granulata Linnarsson.
subsidua White.
Bohemica Barrande.
= *Obolus ? Bohemicus* Barrande (Syst. Sil. Bohême, vol. v, p. 102, pl. vii, figs. 1*a*, 2*a*, 3*a*).
Acrothele Matthewi, Hartt (sp.) (U. S. Geol. Survey, Bull. No. 10, p. 15, pl. i, figs. 4, 4*a*).

Acrothele ? dichotoma Walcott (Monographs United States Geological Survey, vol. viii, p. 14, plate ix, fig. 11) is quite as properly referred to the genus Acrotreta. Omitting this, all the known species are from the Cambrian or first fauna.

There is a striking similarity in all the species yet described, and a comparison of specimens appears necessary to distinguish between *A. Bohemica*, *A. coriacea*, and *A. Matthewi*, and *A. granulata* and *A. subsidua.*

ACROTHELE SUBSIDUA White.

Plate ix, figs. 4, 4*a*–*c*.

Acrotreta? subsidua White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid.; Prelim. Rep. Invert. Foss., p. 6. *Idem*, 1875. Same report, vol. iv, pt. 1, p. 34, pl. i, figs. 3*a*–*d*.

Acrothele subsidua White, 1880. Proc. U. S. Nat. Museum, vol. iii, p. 47.

Original description.—"Shell thin, corneous, discoid, subcircular or somewhat suboval in outline, the transverse diameter being a trifle greater than the longitudinal; sides regularly and front broadly rounded; posterior margin slightly straightened, forming a comparatively short, slightly convex, or nearly straight hinge-line.

"Dorsal valve flattened; beak marginal or nearly so, not prominent; interior surface having a slightly elevated median ridge, beginning beneath the beak and extending to about the middle of the valve, where it disappears.

"The condition of all the specimens of this species which the collections contain is such that the muscular impressions are not distinctly shown, but those of the posterior adductors appear to be small and placed nearly beneath the beak, one on each side of the median ridge just mentioned; between these muscular impressions and the posterior margin there is at each side an obscure diverging ridge or fold, which seems to blend with the postero-lateral margin.

"Ventral valve moderately convex in the umbonal region, but more flattened anteriorly and laterally; beak eccentric, somewhat prominent, and minutely perforate. Some of the specimens show what appear to be small adductor impressions placed in the apex, close to the foramen, one at each side of it. One specimen shows a slight flattening of the space upon the outer surface, between the apex and the hinge, producing the appearance there of an indistinctly-defined cardinal area.

"The inner surface of both valves of all the specimens of this species contained in the collections has been more or less exfoliated by weathering, whereby some of the principal characters have been obscured. Consequently, the foregoing description is not only incomplete, but it is probable that the discovery of more perfect specimens may show the necessity for modifying it. The cast of a single valve found associated with those used in this description, showing large and distinct muscular impressions, already suggests such a modification; but its characters are not embodied in the description, because that specimen is not certainly known to belong to the species. The specimen referred to is illustrated by figure 3*d*, plate i. The other specimens all show fine radiating lines in the structure of the shell, and also concentric laminæ of growth. They are all compressed in dark shale, and show only the interior surfaces of the valves, none showing the external surface. The latter is supposed to be lamellose or otherwise so roughened as to have caused it to adhere to the shale, while the smooth interior surface has readily separated in the plane of fission."

The outer surface of this species is minutely papillose, the papillæ being arranged in a rough, quincunxial order or irregularly crowded together along the spaces between the concentric lines of growth. This surface was found on specimens from the typical locality at Antelope Springs, and also on others from Pioche, Nevada.

Acrothele granulata Linnarsson is a very closely related species, and it is difficult to give specific differences between them on a comparison of the ventral valves, which is all that has been found of the Swedish species.

Acrothele Matthewi Hartt (see United States Geological Survey, Bulletin No. 10, p. 15) is very much like *A. subsidua*. Like *A. subsidua*, the outer granulated surface is rarely seen, as it clings to the matrix, taking a thin coating of shell with it.

Formation and localities.—Middle Cambrian. Calcareous shale at Antelope Springs, Utah, in association with *Ptychoparia Kingi*, *Asaphiscus Wheeleri*, &c. At Pioche, Nevada, it is in an argillaceous shale with *Olenellus Gilberti.*

Genus OBOLELLA Billings.

Obolella Billings, 1861. Geology of Vermont, vol. ii, p. 946. *Idem*, 1865. Pal. Foss. vol. 1, p. 7. *Idem*, 1872. Can. Nat., new ser., vol. vi, p. 217. *Idem*, 1872. Amer. Jour. Sci., 3d ser., vol. iii., p. 355. *Idem*, 1876. Same jou vol. xi, pp. 176–178. *Idem*, Hall, 1863. Sixteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 131. *Idem*, Ford, 1881. Amer. Jour. Sci., 3d ser., vol. xxi, p. 131.

Dicellomus Hall, 1873. Twenty-third Rep. N. Y. State Cab. Nat. Hist., p. 246. Type *O. crassa*.

Original description. "*Generic characters.*—Shell ovate-circular or subquadrate, convex or plano-convex. Ventral valve with a false area, which is sometimes minute and usually grooved for the passage of the peduncle. Dorsal valve either with or without an area. Muscular impressions in the ventral valve, four, one pair in front of the beak near the middle, or in the upper half of the shell, and the others situated one on each side near the cardinal edge. Shell calcareous; surface concentrically striated, sometimes with thin extended lamellose ridges.

"In general form these shells somewhat resemble *Obolus*, but the arrangement of the muscular impressions is different. In *Obolus* the two central scars have their smaller extremities directed downwards, and converging towards each other, but in this genus the arrangement is exactly the reverse."

Type, *Obolella chromatica*.

Later, 1872, Mr. Billings redefined the genus; in 1876 he more fully described the type species, accompanying it with figures, two of which we reproduce, together with the description.

Fig. 9.

Fig. 10.

FIG. 9.—Diagram showing the position of the scars of the ventral valve of *O. chromatica*.
FIG. 10.—Diagram showing the position of the scars of the dorsal valves (after Billings).

"*Generic characters.*— Shell unarticulated, ovate or sub-orbicular, lenticular, smooth, concentrically or radiately striated, sometimes reticulated by both radiate and concentric striæ. Ventral valve with a solid beak and a small more or less distinctly grooved area. In the interior of the ventral valve there are two elongated sublinear or petaloid muscular impressions, which extend from near the hinge line forward, sometimes to points in front of the mid-length of the shell. These are either straight or curved, parallel with each other or diverging towards the front. Between these, about the middle of the shell, is a pair of small impressions, and close to the hinge line a third pair, likewise small, and often indistinct. There is also, at least in some species, a small pit near the hinge line, into which the groove of the area seems to terminate. In the dorsal valve there are six impressions corresponding to those of the ventral valve, and sometimes an obscure rounded ridge along the median line.

"If we compare the interior of the ventral valve of an *Obolella* with that of *Obolus Apollinis*, we see that there are six muscular impressions in each, but not arranged in the same manner. The two small scars *aa* at the hinge line are most probably the same in both genera. The two lateral scars *bb* of *Obolus* have no homologue in *Obolella*, unless they be represented by the two large ones, *dd*. Should this be the case, however, the great difference in their position would no doubt be of generic value. I think it more probable that the large scars *dd* of *Obolella* represent the central pair *cc* of *Obolus*. Again, Eichwald says that in the interior of the ventral valve of *O. Apollinis* there is a longitudinal septum (shown in the above fig. at *s*), which separates the two adductors, *cc*, and extends to the cardinal groove (I suppose he means the groove *g* on the area). No such septum occurs in any species of *Obollela*. I have not seen any description of the dorsal valve of the *O. Apollinis* sufficiently perfect to afford a means of comparison with that of *Obolella*, but the differences in the ventral valve alone are so great that the two genera can scarcely be identical. They are, however, closely related, and occur in nearly the same geological horizon."

In the rocks below Quebec and at the Straits of Belle Isle, we find the following species of *Obolella* :

1. "*O. desquamata* Hall = *Avicula? desquamata*, Pal. N. Y., vol. i, p. 292, pl. 80, fig. 2. Occurs at Troy, New York.

"2. *O. crassa* Hall = *Orbicula ? crassa*, op. cit., p. 299, pl. 79, fig. 8. Occurs at Troy.
"3. *O. cælata* Hall = *Orbicula cælata*, op. cit., p. 290, pl. 79, fig. 9. Occurs at Troy.
"4. *O. gemma*, n. sp.
"5. *O. Circe*, n. sp.
"6. *O. chromatica* Billings has been found as yet only at the Straits of Belle Isle."

Of the species enumerated above, *O. desquamata* has been united with *O. crassa* and *O. cælata* is referred to the genus Lingulella by Mr. Ford.

Obolella desiderata Billings (Pal. Foss., vol. i, p. 69) is not a true Obolella, but a form that with *Obolella ? ambigua* Walcott (Monographs U. S. Geol. Survey, vol. viii, Pal. Eureka Dist., p. 67, pl. i, figs. 2*a–c*) will form a new genus or subgenus of the Obolidæ. Both species occur at the same relative geologic horizon at the base of the Lower Silurian (Ordovician) or Calciferous Group of the New York State section.

Obolella pretiosa Billings (Pal. Foss., vol. i, p. 68) is more closely related to the genus Acrothele than to Obolella, and, with the type specimens before me, I cannot make a generic reference that is at all satisfactory. We must await the discovery of specimens showing the interior of the shell.

Obolella Ida Billings (Pal. Foss., vol. i, p. 71) is very doubtfully referred to Obolella. Like *O. pretiosa* it will require better material for study before a satisfactory generic reference can be made of it.

Obolella polita Hall (sp.) (Sixteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 133, pl. vi, figs. 17–21). This species departs further from the type *O. chromatica* in the size of the muscular scars than any of the Middle Cambrian species, but their system of arrangement is essentially the same as far as I have yet been able to determine.

Obolella Nana M. and H. (Pal. Upper Missouri, p. 4, pl. 1, figs. 3*a–d*). The collections of the National Museum contain the types of this species used by Meek and Hayden, and also a large series of *Obolella polita* from various localities in Wisconsin. A comparison between the Black Hills specimens on which *O. Nana* was founded with the latter prove them to be the same. Figures 3*c*, 3*d* of Meek and Hayden show the interior of the ventral valve, and figures 3*a*, 3*b*, the exterior of the dorsal valve. All the characters shown in the types of *O. Nana* are well shown in specimens of *O. polita* from the Potsdam sandstone of Eau Claire, Wisconsin.

Obolella discoidea H. and W. (Geol. Expl. Fortieth Par., vol. iv, p. 205, pl. i, figs. 1, 2). This species must remain doubtfully referred to the genus until interiors of the valves are discovered. It recalls *O. ? Ida*, when imbedded in a hard limestone matrix.

Obolella transversa Hartt = *Linnarssonia transversa* (Amer. Jour. Sci., 3d ser., vol. xxix, p. 115).

Obolella miser Billings (Pal. Foss., vol. ii, p. 69). This species is referred to the genus Linnarssonia by Mr. G. F. Matthew, in a letter to the writer.

When the detailed study of the Upper Cambrian fauna is taken up, the various species from that horizon will be studied and illustrated, and then we shall have data for a more extended and accurate comparison of all the species belonging to the genus.

OBOLELLA CHROMATICA Billings.

Plate xi, figs. 1, 1*a*, *b*.

Obolella chromatica Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 947, figs. 346*a–d*. *Idem*, 1863. Geology of Canada, p. 284, figs. 288*a–d*. *Idem*, 1865. Pal. Foss., vol. i, p. 7, figs. 7*a–d*. *Idem*, 1876. Amer. Jour. Sci., 3d ser., vol. xi, p. 176, figs. 1, 2, 3; p. 177, figs. 4*a–d*. *Idem*, Ford, 1881. Amer. Jour. Sci., 3d ser., vol. xxi, p. 133, figs. 3, 4.

Original description.—"Broad oval, the rostral extremity obtusely pointed, front broadly rounded, greatest width a little below the middle; both valves rather strongly and uniformly convex, most tumid at about one-third the length from the beak. Ventral valve more acute above than the dorsal, beak depressed below the greatest elevation of the shell, slightly elevated above the margin, with a small area beneath it which is inclined backward at an angle which varies from 45° to 60°. Dorsal valve with an obtusely rounded umbo, the beak scarcely distinct from the cardinal edge and not elevated above the margin. Surface, with fine concentric striæ or small minutely rugose ridges of growth, of a variable size, from four to eight in one line, often smooth from exfoliation or wearing. Color of the shell in the reddish limestone a honey-yellow, in gray limestone grayish; when exposed to the weather becomes white and minutely fibrous.

"Length and breadth about three lines.

"In some specimens the ventral valve is depressed convex, the beak being on a level with the greatest elevation of the shell. The shell is thick and strong, and when well preserved breaks with a granular fracture. When weathered a tendency to fibrous exfoliation is manifested.

"This species is closely allied to the form that is found so abundantly in the Troy limestone, but the muscular impressions in that one are rather closer together and nearer the beak. (At least they are so in the specimens in my possession.)

"Many of the specimens are a little more obtuse in the upper half than those figured. The individuals are exceedingly numerous and differ little in size."

In 1876 Mr. Billings added the following details of the interior of the valves:

"In the ventral valve there is a groove in the hinge line for the passage of the pedicle. On each side of the grove there is a small, somewhat deeply excavated, cardinal scar. In the cavity of the valve there are two elongated scars, which extend from near the cardinal scars forward about two-thirds of the length of the shell. These diverge from each other, more or less, in their extension forward, and are usually curved, but sometimes nearly straight. They may be called laterals. They are, in general, separated from each other about one-third of the width of the shell. A little above the mid-length, and between the two laterals, there is a pair of small scars arranged transversely, with their inner extremities directed somewhat forward. The space above these two scars, between the upper portion of the laterals, is generally tumid from the thickening of the shell. In one of the specimens there is a small pit in the center of this space.

"The dorsal valve has a small area, or nearly flat hinge facet. The minute beak is slightly incurved over the edge of the area. Beneath the beak there is a small subangular ridge, on each side of which there is a cardinal ? scar. The elongated scars, which seem to correspond to the laterals of the ventral valve, are here altogether in the upper half of the shell. They diverge widely in their extension forward. They are in general very slightly impressed, and would, most probably, escape the observation of any one who did not expect to find scars where they are situated. In the cavity of the valve there is a low rounded median ridge, which extends from a point near the hinge line forward a little below the mid-length of the valve. About the middle of the shell there are two small scars. These are usually striated longitudinally. The median ridge passes between them. The area is coarsely striated.

"The above are the principal characters of this species, and they are subject to some variation, one of which is particularly worthy of notice. The two small cardinal scars of the dorsal valve are sometimes elongated laterally. This is carried to such an extent in another species (*O. gemma*) that they not only extend the whole length of the hinge-line, but are curved forward at their outer extremities and continued down into the cavity of the valve. In such cases they present an appearance similar to that of the groove beneath the hinge-line of the genus *Obolellina*. In other species of this genus the lateral scars of the dorsal valve are sometimes connected together by their upper extremities. But this is not a constant character. In different indivduals of the same species these scars are either connected or not. The laterals are also sometimes connected with the cardinals."

In an interior of the dorsal valve from L'Anse au Loup, now before me, I find that the cardinal ? scars extend down into the cavity of the valve, and also that the central scars on the opposite sides of the median ridge are elongated and have much the same form as those of the same valve in *O. crassa and O. gemma.*

Formation and locality.—Middle Cambrian, associated with *Olenellus Thompsoni* and other fossils characteristic of the Middle Cambrian or Georgia horizon. L'Anse au Loup, on the north side of the Straits of Belle Isle, Canada.

OBOLELLA CRASSA Hall (sp.)

Plate x, figs. 1, 1*a–f*.

Orbicula? crassa Hall, 1847. Pal. N. Y., vol. i, p. 290, pl. lxxix, fig. 8*a*.
Avicula? desquamata Hall, 1847. Pal. N. Y., vol. i, p. 292, pl. lxxx, figs. 3*a*, *b*.
Obolella (*Orbicula?*) *crassa* Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33.
Obolella crassa, *O. desquamata* Billings, 1871. Can. Nat., new ser., vol. vi, p. 218. *Idem*, 1872. Amer. Jour. Sci., 3d ser., vol. iii, p. 356.
Dicellomus crassa Hall, 1873. Twenty-third Rep. N. Y. State Cab. Nat. Hist., p. 246, pl. xiii, figs. 6–9.
Obolella crassa Ford, 1881. Amer. Jour. Sci., 3d ser., vol. xxi, p. 131, figs. 1, 2.

The original description of the species appears to be that of the exterior of the ventral valve, and is as follows: "Ovate-orbicular, with the apex near the narrow extremity; apex obtuse; surface marked by strong concentric wrinkles and fine radiating striæ.

"These characters are preserved in the cast, a small portion only of the shell remaining upon the specimen.

"*Position and locality.*—This species was found in the intercalated calcareous strata, among the shales of the Hudson River group, two miles northeast of Troy."

Mr. Billings, in 1861 (Geol. Vermont, vol. ii, p. 947), thought that *Avicula? desquamata* Hall might be referred to the genus, and in 1871 Mr. Ford referred *Orbicula? crassa* Hall to Obolella. Later, in 1877 (Amer. Jour. Sci., 3d ser., vol. xv, p. 128), the latter observer placed *Avicula? desquamata* as a synonym of *O. crassa*, saying: "The species known as *Obolella crassa* of the Troy beds may also be briefly noticed in this connection. It includes the species already widely known under the name of *O. desquamata*, from the same locality, this latter, as may be shown, having been founded upon the dorsal valve of the former. The ventral valve is always more acutely pointed at the beak than the dorsal, but beyond this feature there is nothing, so far as I have been able to discover, by which they may be distinguished from each other externally. The surface of each, when perfect, is both radiately and concentrically striated. As a rule, however, the imbricating edges of the successive layers of growth are the only markings visible.

"Of the interior of the ventral valve an excellent figure was given by Mr. Billings (Amer. Jour. Sci., 3d ser., vol. iii, May, 1872, p. 355); but the interior markings of the dorsal valve have nowhere, to my knowledge, yet been accurately shown. The scars are nearly the same with those of the dorsal valve of *O. chromatica*, but the smaller pair close to the beak are here, in the majority of cases, distinctly connected with the larger pair directly beneath them; while the central pair, instead of running parallel with each other throughout, diverge at the mid-length of the valve, and extend onward in slender falcate forms into the anterior fourth of the shell. Their parallel portions are, however, the only parts usually seen, and it was only after collecting the species for a number of years that I obtained evidence that what had come to be looked upon as wholes were, in reality, only parts of much more extensive impressions."

The species was more fully described by Mr. Ford, in 1881, under remarks on the genus Obolella (Amer. Jour. Sci., 3d ser., vol. xxi, pp. 131, 132).

"The shell of *Obolella crassa* is suborbicular, with the beak of either valve extending slightly beyond the peripheral contour. As a rule, the beak of the dorsal valve is curved downward so as to almost touch the short, indistinct hinge-line, while that of the ventral valve is less depressed and slightly more projecting; and these are the only features by which the two valves may be externally distinguished. The majority of the specimens of the ventral valve have an extremely shallow depression running from the beak to the anterior margin along the median line; but I have found that even this is not distinctive, inasmuch as some of the dorsal valves exhibit it. The specimens in my possession vary in length and breadth from 1½ to 6 lines, the two diameters being generally nearly equal. The surface of both valves, when perfect, is both radiately and concentrically striated. The shell is thick and solid, showing no tendency to break up into successive laminæ on weathering. I have had portions of it ground and polished for microscopic examination, but am unable to make out any definite structure.

"In the interior of the ventral valve there are two small, ovate muscular scars, situated close to the beak, one on either side of the pedicle groove; and immediately in advance of these a pair of large, elongate, curved scars, which sometimes extend forward into the anterior fourth of shell. Between these latter, and somewhat above the mid-length of the valve, there are two small subcircular impressions. All of these scars are, in well preserved specimens, deeply impressed, and, taken together, constitute a conspicuous and beautiful system. There is usually a distinct ridge running along the middle of the large lateral impressions, dividing them at bottom into two portions; and in some cases its wider upper portion is minutely pustulose. The rostral portion of the valve is often much thickened, the several scars bounding the elevation. The interior surface of the forward portion of the valve is marked by fine radiating striæ.

"The dorsal valve possesses a small though distinct area, which is divided into two equal portions by a feeble longitudinal ridge. The slender cardinal line is delicately notched in the middle, and has immediately in advance of it a deep transverse groove.[1] On either side of the longitudinal ridge referred to, there is a small, ovate, cardinal muscular scar. These scars have their apices directed downward and outward, their upper portions cutting across the extremities of the cardinal line

[1] Fig. 2*h* in original.

and limiting it. Directly in front of the cardinals there are two large impressions of similar shape and direction, the laterals, which extend forward to the mid-length of the shell. These two pairs of impressions are frequently connected with each other by the passage of the cardinals down into the laterals; but, as will be seen, they are not so connected in the specimen figured, which has been selected in order to illustrate more clearly their essential independence. In the central portion of the valve there is a pair of still larger impressions,[1] having their upper portions parallel and their lower, falcate parts widely diverging. Between their parallel portions there is a low mesial ridge, which dies out before reaching the hinge-line. The falciform portions of these scars are, in general, very faintly impressed, and might readily escape observation. The interior surface is usually smooth."

In specimens from a light-gray, granular limestone, the tendency of the shell to break on the surface and show successive laminæ is quite pronounced, but usually it is, as Mr. Ford says, not so.

The differences between the muscular scars of *O. crassa* and the type of the genus *O. chromatica* are not as marked as I had supposed from the figures given by Mr. Billings and Mr. Ford. A study of the interior of the valves of *O. chromatica* shows that the central scars of the dorsal valve are not unlike those in *O. crassa* and that those of the ventral valve are essentially the same. It is difficult to find two interiors of the same valve in either species exactly alike, a fact owing to the original condition of the scars on the shell and much more to the changes passed through since the death of the animal that inhabited it.

Formation and localities.—Middle Cambrian. In the even-bedded and conglomerate limestone on the ridge east of the city of Troy, New York; at the same geologic horizon one mile below Schodack Landing, in Columbia County, New York; also, at St. Simon and at Bic Harbor, on the St. Lawrence River below Quebec, Canada.

OBOLELLA GEMMA Billings.

Plate x, figs. 2, 2*a–e*.

Obolella gemma Billings, 1872. Can. Nat., new ser., vol. vi, p. 218, fig. 5, of p. 217.

Original description.—"Shell very small, about two or three lines in length, ovate, both valves moderately convex and nearly smooth. Ventral valve ovate, the anterior margin broadly rounded, with sometimes a portion in the middle nearly straight; greatest width at about one-third the length from the front, thence tapering with gently convex or nearly straight sides to the beak, which is acutely rounded. The area is about one-fifth or one-sixth the whole length of the shell, with a comparatively deep groove, which extends to the apex of the beak. The dorsal valve

[1] *c c* in original.

is nearly circular, obscurely angular at the beak, and rather more broadly rounded at the front margin than at the sides.

"In the interior of the ventral valve there are two small muscular impressions of a lunate form, close to the cardinal margin, one on each side of the median line. A second pair consists of two elongate sub-linear scars, which extend from the posterior third of the length of the shell to points situated at about one-fourth the length from the front margin. These scars are nearly straight, parallel or slightly diverging forwards, and divide the shell longitudinally into three nearly equal portions. Between them, about the middle of the shell, are two other small obscurely-defined impressions. There is also a small pit close to the hinge line and in the median line of the shell. In the interior of the dorsal valve there is an obscure rounded ridge, which runs from the beak along the median line almost to the front margin. Close to the hinge line there is a pair of small scars, one on each side of the ridge. The other impressions in this valve have not been made out.

"The surface of both valves is in general nearly smooth, but when well preserved shows some obscure concentric striæ."

When breaking up some bits of limestone from Bic Harbor, obtained from the Geological Survey of Canada, I found a comparatively perfect interior of the dorsal valve of this species that shows two rather large elongate scars near the cardinal margin, a median groove channeling the beak, a depressed area just in front of the latter that is bounded on either side by a strong ridge that unites in front of it, a faint muscular scar or scars showing just in front of the point of union; laterally a ridge passes off from each side and gradually diminishes as it advances into the cavity of the valve. In another example the elevated ridges are nearly lost, probably by the compression of the shell.

A beautifully preserved interior of the ventral valve from Troy, New York, shows the muscular scars in a better state of preservation than any I have seen from Bic Harbor; nearly all the specimens from the latter place appear to have been partially macerated and then more or less compressed before the consolidation of the sediment. The principal defect in the Troy specimen is the obscure character of the elongate lateral scars. The shell also shows radiating lines that appear to have been color lines in the original shell. Specimens from Bic Harbor show the various features seen in the Troy specimens, but not in as perfect a condition in any one specimen.

I do not think there is much doubt of the identity of the shells found at Troy with those from Bic Harbor.

Formation and localities.—Middle Cambrian. In the conglomerate limestones of St. Simon and Bic Harbor, on the St. Lawrence River, below Quebec, Canada. Mr. Ford discovered the species on the ridge east of Troy, New York, in association with other well-known fossils of the Middle Cambrian fauna.

OBOLELLA CIRCE Billings.

Plate x, figs. 3, 3a

Obolella Circe Billings, 1872. Can. Nat., new ser., vol. vi, p. 219.

Original description.—"Ovate, front and sides uniformly rounded; posterior extremity more narrowly rounded than the front, length and width about equal, greatest width at the mid-length, rather strongly and uniformly convex, surface nearly smooth, but with fine concentric striæ. Length, seven lines; width, a little less. The rostral portion of the shell is much thickened for about one-fifth the length, and in this part there is a deep and wide groove. In front of the thickened portion the muscular impressions are indistinctly seen, but appear to be formed on the same plan as those of the ventral valve of the genus.

"The above description is drawn up on one exterior and several interiors of the same valve, apparently the ventral valve. The exterior is very like that of *O. desquamata*, and is of the same size, but the interior shows it to be an entirely distinct species.

"Length of the largest specimens seen, seven lines; width, about the same or slightly less."

Through the kindness of Professor Whiteaves I was permitted to study all the specimens of this species in the collection of the Geological Survey of Canada. Specimens of the valve described by Mr. Billings as the ventral show the deep rostral cavity, from the anterior side of which a ridge extends forward on each side into the cavity of the valve, much as in *O. gemma*; inside of these there are two narrow elongate scars and two oblong central scars; a number of elevated radiating striæ cross the central portions of the interior and extend more faintly nearly to the frontal margin.

But one interior of the dorsal valve was observed. This shows the same character of area as *O. crassa*; the lateral scars are of the same character, but the central scars are confined more to the rostral half of the valve.

Formation and locality.—Middle Cambrian. Limestone conglomerate at Trois Pistoles, on the St. Lawrence River, below Quebec, Canada.

OBOLELLA NITIDA Ford.

Plate xi, fig. 2.

Obolella nitida Ford, 1873. Amer. Jour. Sci., 3d ser., vol. v, p. 213.

Original description.—"Shell transversely suboval, small. Dorsal valve gently but irregularly convex, the greatest elevation occurring at a point about one-fifth the length of the valve from the apex. From this point the beak curves sharply down to the hinge line, which it almost touches. The hinge line itself is slightly curved and apparently equal to about one-third the width of the shell. At the most elevated point of the valve commences a well-defined median depression, which extends forward for a distance of about one-half the length of the valve, gradually widening and becoming more shallow till it disappears. A portion of the dorsal valve close to the margin is sometimes nearly flat all around. The internal markings are not well enough shown in any of the specimens that I have seen to admit of description. The surface is ornamented with very fine concentric striæ and numerous close-set radiating striæ, the whole just visible to the unassisted eye.

"The ventral valve is not certainly known. The width of the largest dorsal valve that I have seen is 0.14 of an inch and the length 0.10 of an inch."

The above description and the figure of a type specimen are all that we have of the species.

Formation and locality.—Middle Cambrian. Even-bedded and conglomerate limestones on the ridge east of the city of Troy, New York.

Genus ORTHIS Dalman.

Orthis Dalman, 1827. See Brit. Foss. Brach., vol. i; Genl. Introduction, p. 101.

ORTHIS ? HIGHLANDENSIS n. sp.

Plate viii, figs. 3, 3*a*, *b*.

Shell about the average size of the Cambrian species, but below the size of those from the Silurian. Transversely oval or subrotund, front broadly rounded and nearly straight in the dorsal valve; hinge line shorter than the greatest width of the shell. Ventral valve moderately convex, most elevated toward the beak, which is slightly arched over to meet the nearly perpendicular area; mesial sinus broad and shallow or nearly obsolete; area flat; foramen unknown. Dorsal valve associated in the same hard specimens of limestone, more convex than the ventral valve; hinge line very short; median fold but slightly raised above the general surface; area unknown. Surface marked by concentric lines of growth and finer striæ. No traces of radiating costæ are seen except on the interior of the shell towards the margin.

Casts of the interior of the ventral valve show the dental plates, median ridge and bifurcating ridges extending nearly to the margin; also, two lateral grooves. The specimens of the interior of the dorsal valve show only faint impressions of a large oval scar each side of the median line.

The form of the dental plates, the prolonged ridges, and the short median ridge of the ventral valve associate this species with Orthis rather than Orthisina. The interior of the ventral valve allies it closer to *O. Pepina* Hall (Sixteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 134, pl. vi, figs. 23–27) of the Wisconsin and Texas Upper Cambrian (Potsdam) horizon than to the species of the Middle Cambrian, unless it be *Orthisina ? Orientalis.* It is to be regretted that we have not better material for the study of this and the species placed under Orthisina.

Formation and localities.—Middle Cambrian. In the limestone with *Olenellus Gilberti*, *Olenoides levis*, &c., at Pioche, and also on the west side of the Highland Range, 11 miles north of Bennet's Springs, and at the south end of the Timpahute Range, Groome District, Nevada.

Genus ORTHISINA D'Orbigny.

Orthisina D'Orbigny, 1849. See Brit. Foss. Brach., vol. i, Genl. Introduction, p. 104.

ORTHISINA ORIENTALIS Whitfield.

Plate vii, fig. 6.

Orthisina Orientalis Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. i, p. 144, pl. xiv, fig. 6.

Original description.—"Shell quadrangular in outline, somewhat higher than wide, with vertical and sub-parallel lateral margins, and broadly rounded base. Cardinal line rapidly sloping from the apex to the extremities, which are slightly rounded. Hinge line straight, as long as the greatest width of the shell. Cardinal area broad and high, divided in the middle by a triangular foramen, which is about as high as wide. Surface of the ventral valve moderately convex, marked by very fine radiating striæ and also by several concentric lines of growth. Filling of the rostral cavity and foramen large and prominent. Specimen, a cast in shale, of the ventral valve only."

The specimen described above is flattened in the shale and also apparently compressed laterally. Uncompressed specimens referred to this species, from intercalated limestone beds ("lentile") in the shales east of Swanton, show it to have been moderately convex, and also specifically distinct from *O. Pepina* of the Potsdam group in Wisconsin and in Texas.

Formation and localities.—Middle Cambrian, Georgia Formation. Silico-argillaceous shales; Parker's quarry, town of Georgia, and in a gray limestone "lentile" two miles east of Swanton, Vermont, at about the same relative geologic horizon.

ORTHISINA FESTINATA Billings.

Plate vii, figs. 7, 7*a*, *b*.

Orthisina festinata Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 949, figs. 350–352. *Idem*, 1863. Geol. Canada, p. 284, figs. 289*a–c*. *Idem*, 1865. Pal. Foss., vol. i, p. 10, fig. 11.

Original description.—"Subquadrate or semi-oval, hinge line equal to the greatest width of the shell. Ventral valve subpyramidal, beak elevated, surface with a straight or slightly convex slope in all directions to the margin, area triangular, a little inclined backwards, foramen about as wide as high, closed by a convex deltidium which is perforated at the beak. Dorsal valve nearly flat. Surface with angular bifurcating ribs, five or six in the width of two lines at the margin, crossed by fine concentric striæ, of which there are from seven to ten in one line.

"Width on hinge line from ten to fifteen lines; length about one-third less than the width. Height of central valve from two to three lines.

"Both valves show longitudinal undulations radiating from the beak to the margin.

"This species closely resembles some of the ordinary forms of the genus, but differs internally from any known to me in the Second Fauna in the absence of the dental plates, no traces of which can be perceived in the casts."

Specimens were collected from a limestone in the typical locality, but no casts of the interior were found. The radiating costæ are finer and more numerous than those on the cast figured by Mr. Billings, but in other characters they appear to belong to the same species. East of Highgate Springs the species is quite abundant in a hard, arenaceous, magnesian limestone, and shows the costæ to have been roughened by spinous projections and also by rather strong concentric lines of growth. These characteristics are also preserved in a cast from the argillaceous shale of Parker's quarry. Several illustrations are given of specimens from different localities.

Formation and localities.—Middle Cambrian, Georgia Formation. In limestone "lentile" about two miles east of Swanton; in silico-argillaceous shales, with *Olenellus Thompsoni*, Parker's quarry, town of Georgia; and in arenaceous magnesian limestone about two miles east of Highgate Springs, Franklin County, Vermont.

ORTHISINA? TRANSVERSA n. sp.

Plate vii, figs. 5, 5*a*.

Shell small, transversely subquadrangular in outline, front broadly rounded, angle formed by the union of the cardinal slopes of the ventral valve 155° to 165°, hinge line straight and as long as the width of the shell. Area of the ventral valve of moderate height, bent back from the hinge line, divided by a triangular foramen that is higher than wide and covered by a convex deltidium; the area of the dorsal valve is bent back at more than right angles to the hinge line; foramen higher than wide, covered by a deltidium.

Surface marked by numerous radiating, fine, even costæ, eight in a distance of 3^{mm}, on the frontal margin of the ventral valve; a few concentric lines of growth cross the radiating costæ, but not so as to give them a nodose character.

Interior characters unknown. The fine radiating striæ and transverse form distinguish this from other described species known to me.

Formation and locality.—Middle Cambrian, Georgia Formation. Silico-argillaceous shales of Parker's quarry, town of Georgia, Franklin County, Vermont.

ORTHISINA? (sp. undt.)

There are two species represented by fragmentary material that appear to be distinct from any described. One occurs east of Highgate Springs, the other at Parker's quarry.

Two undescribed species of Orthis or Orthisina, from L'Anse au Loup, on the Straits of Belle Isle, Labrador, that have not yet been described, occur in the collection of the Geological Survey of Canada.

Genus CAMARELLA Billings.

Camarella Billings, 1859. Can. Nat., vol. iv, p. 301.

Original description.—"Family Rhynchonellidæ; ventral valve, with a small triangular chamber beneath the beak, supported by a short mesial septum as in *Pentamerus*. Dorsal valve, with a single mesial septum and two short lamellæ for the support of the oral appendages, as in *Rhynchonella*."

The type of the genus is *C. Volborthi*, the description of which follows that of the genus, and, on page 143 of The Geology of Canada, 1863, illustrations are given, figs. 77*a*, *b*, *c*. The species referred to the genus from the Middle Cambrian may belong to it, but we have only the general external resemblance on which to accept the generic reference. The second species mentioned in the list of species is more like *Triplesia primordialis* (Geol. Wis., vol. iv, p. 172, pl. x, figs. 1 and 2, 1882) than any other species with which I am acquainted. The only specimens now known to me of the second species are in the collections of the museum of the Geological Survey of Canada, and have not yet been described.

CAMARELLA ANTIQUATA Billings.

Plate vii, fig. 8.

Camarella antiquata Billings, 1861. Pamphlet; Geology of Vermont, vol. ii, p. 949, fig. 353. *Idem*, 1863. Geol. Canada, p. 284, fig. 290. *Idem*, 1865. Pal. Foss., vol. i, p. 10, fig. 13.

Original description.—"Ovate or subcircular, beaks obtusely pointed (as seen on the cast), both valves moderately or rather strongly convex. Surface with from eight to ten small rounded ribs which do not reach quite to the beaks.

"Some of the specimens are proportionally more elongated than others. The front margin appears to be always broadly rounded, and the greatest width at about one-fourth the length from the front margin.

"Length, from 4 to 6 lines; width, either equal to or a little less than the length.

"This species resembles *C. varians* of the Chazy, but is more numerously ribbed."

We have seen but two specimens of the cast of a single valve of this species and cannot add to the description given by Mr. Billings.

Formation and locality.—Middle Cambrian, Georgia Formation. About 2 miles east of Swanton, Vermont.

LAMELLIBRANCHIATA.

Genus FORDILLA Barrande.

Fordilla Barrande, 1881. Acéphalés. Études Loc. et Comp. 8°. Description of pl. 361.

The first notice we have of this interesting genus is by Mr. S. W. Ford (Amer. Jour. Sci., 3d ser., vol. vi, p. 139, 1873), who called attention to it under the title of "Bivalve of uncertain class; gen. nov.?" He described it as follows:

"Shell transversely oblong or suboval in outline, convex, widest posteriorly, narrowed at either extremity, with an oblique posterior ridge, and small depressed umbones situated anteriorly, sometimes presenting an obscurely bi-lobed appearance in front. Dorsal margin nearly straight, ventral margin uniformly rounded. In the interior of the left valve, as shown by a gutta-percha cast of an impression in stone of this valve, there is a wide and deep furrow with a slightly raised line along the middle of it, corresponding to the oblique ridge on the outside; and a distinctly impressed line passing from the lower anterior into the upper posterior portion of the valve, following the curved ventral edge, from which it is separated by a broad flattened border. This line is deeply sunken anteriorly, becomes almost obsolete or discontinuous in passing the oblique internal furrow, beyond which, in the posterior portion of the shell, it is less distinct, though clearly shown. Just in front of and above the anterior limit of this line there is a slight conical protuberance. Further than this nothing can be made out, owing to the imperfection of the material. The shell is thick, with the surface finely striated concentrically.

"I have never observed a specimen of this singular little shell with the two valves together, but they are frequently found side by side in the same hand specimen of stone.

"Length, rarely more than 0.16 of an inch; usual width, about 0.10."

Subsequently Mr. Ford sent specimens to M. Barrande, who proposed the above generic name and gave several excellent figures, but refrained from publishing a generic and specific description.

Mr. Ford remarks before his description: "Externally they [the single valves] present something of the appearance of a small *Modiolopsis*. As no undoubted lamellibranchiates have, however, been hitherto detected in strata certainly more ancient than the Calciferous Sandrock, it is quite possible that, when they come to be better understood, they will be found to belong to some as yet imperfectly known group of crustaceans." Mr. Ford, however, was *strongly inclined to the* belief that they were lamellibranchs, and in this I agree with him.

M. Barrande says (Acéphalés. Études Loc. et Comp., 8°, pp. 391–393):

"L'impression qui est résultée de ces études dans notre esprit se résume en quelques mots:

"D'après leurs apparences extérieures, ces petites valves pourraient être considérées comme appartenant à un lamellibranche.

"Au contraire, les apparences des moules internes offrent des caractères que nous n'avons jamais observés sur les moules correspondants des Acéphalés.

"La description de M. Ford, dont la majeure partie est consacrée à la surface du moule interne de l'une des valves, constate l'importance de ces apparences insolites et confirme bien nos impressions.

"Nous sommes donc disposés à considérer ces petites coquilles comme appartenant à un Crustacé primordial et nous rappelons qu'un autre Crustacé coexistant est énuméré par M. Ford, sous le nom de *Leperditia Troyensis*, dans le tableau que nous venons de reproduire.

* * * * * * *

"Ainsi, on remarquera qu'il n'existe sur le contour de la charnière des valves de Troy aucune trace de séries de dents, comme dans les *Nucula* et autres genres anciens.

"On constatera de même, sur ces petites valves, l'absence de toute impression musculaire, comparable à celles qui sont habituellement très bien conservées dans le même genre *Nucula* et dans beaucoup de types des faunes les plus anciennes.

* * * * * * *

"D'après ces considérations, nous ne pouvons pas admettre que la preuve de l'existence des lamellibranches dans la faune du Grès de Potsdam soit établie par les petits fossiles de Troy. Nous devons laisser à l'avenir le soin de nous fournir des informations finales et indiscutables au sujet de leur nature, aujourd'hui problématique."

Fordilla Troyensis may be the shell of a crustacean, but I think it is extremely improbable.

The exterior appearance and thickness of the shell united to the probability that a muscle scar exists nearly in the same position as in the genus Modiolopsis, leads me to consider the shell as belonging to the lamellibranchiata. Just in front of the little rounded boss described by Mr. Ford, there is a minute flat depression in two examples that strongly suggests a muscle scar. In casts of the interior of the same shells, hardly a trace of the strong interior ridges and lines shown in other casts of the interior one is to be seen. When we consider the minute size of the shell and that it is separated by a great duration of time from the Calciferous formation, in which the first undoubted lamellibranchiate shell has been found, it is evident that we will not find the same structure as in the lamellibranchiate shells of the Lower Silurian (Ordovician).

FORDILLA TROYENSIS Barrande.

Plate xi, figs. 3, 3*a–c*.

The references and description are the same as that of the genus Fordilla.

Formation and localities.—Middle Cambrian. On the ridge east of the city of Troy, New York, and also one mile south of Schodack Landing, in Columbia County, New York.

GASTEROPODA.

Genus SCENELLA Billings.

Scenella Billings, 1872. Can. Nat., new ser., vol. vi, p. 479; Pal. Fossils, vol. ii, p. 77.

The generic description and the specific description of the type species were given together. We now have *Scenella retusa* Ford and *S. conula* and *S. varians* Walcott to add to the type *S. reticulata*, and the generic description may be separated from that of the type species, as follows:

Small subconical, patelliform shells; aperture elongate oval to nearly circular; apex usually eccentric. Surface smooth or marked with fine concentric striæ or both concentric and radiating striæ.

I now have before me two specimens of *S. reticulata* that are supposed to be the types, as no others are known in the collection of the Geological Survey of Canada and they are from the typical locality. The shell is calcareous, and, in appearance, a smooth species of the genus Stenotheca. The carina spoken of by Mr. Billings is exceedingly obscure, and is not discernible at all in one of the specimens. *Scenella retusa* Ford has a carina on the side opposite the direction of the curvature of the apex, and also two faint lines running down the opposite side from the carina. *S. conula* Walcott (Monographs U. S. Geol. Survey, vol. viii, p. 15, pl. ix, fig. 6) shows a faint line on one of the more elongate sides, while *S. varians* has, so far as known, a smooth surface. The above species form a group of small, patella-like shells that differ from the species referred to Stenotheca in their surface characters, and I think Mr. Billings acted wisely in proposing a generic name to include them.

Stenotheca elongata and *Scenella conula* (Monographs U. S. Geol. Survey, vol. viii) were referred to the Pteropoda, but I now place them under the Gasteropoda.

SCENELLA RETICULATA Billings.

Plate xii, figs. 6, 6*a*.

Scenella reticulata Billings, 1872. Can. Nat., 2d ser., vol. vi, p. 479.

Original description. — "Shell small, almost uniformly depressed, conical; apex central or nearly so; an obscure carina extending from the apex down one side to the margin. Aperture nearly circular, apex very slightly incurved towards the side opposite the carina. Surface reticulated with fine radiating and engirdling striæ, just visible to the naked eye. Diameter of the aperture of the largest specimen collected, 3 lines; height of apex, 2 lines."

A larger specimen, now in the collection of the Canadian Geological Survey, has at the aperture a length of 14^{mm} and a breadth of 11^{mm}, height, 6^{mm}. The apex is eccentric and curved over beyond the highest point of shell. A smaller specimen has a pointed and more nearly concentric apex.

Formation and locality.—Middle Cambrian. Limestone at Topsail Head, Conception Bay, Newfoundland, associated with *Stenotheca rugosa*, *Iphidea bella*, and *Protypus senectus* var. *parvulus*.

SCENELLA RETUSA Ford.

Plate xii, figs. 3, 3*a*.

Scenella retusa Ford, 1873. Amer. Jour. Sci., 3d ser., vol. v, p. 213, figs. 2*a*, *b*, on p. 214.

Original description.—"Shell small, rather strongly convex, aperture ovate, sides curved. Apex obtuse, nearly central, curving down a little toward one side. On the side toward which the apex is directed there are two faint grooves commencing near the tip of the apex and diverging to the margin. On the side opposite there is a well-marked carina running from the apex to the margin along the line of the longer axis of the shell. The slope of the shell is unequal, being most rapid toward the margin to which the apex inclines. The surface is marked by a few fine concentric and radiating lines, the latter only visible under a magnifier, and with obscure imbricating lines of growth.

"Length of the largest specimen obtained, 0.16 of an inch; height, about 0.08 of an inch. Occurs in both even-bedded and conglomerate limestone of the Potsdam group at Troy, associated with the preceding species collected by the writer.

"This species is closely related to *Scenella reticulata*, the only hitherto published species of the genus described by Mr. Billings from the Menevian group of Newfoundland. That species is, however, considerably larger than ours, and is, further, destitute of the diverging grooves which exist in *S. retusa*, and by which this latter species may be easily recognized."

The only specimen known to me of this little shell is in Mr. Ford's collection, and the figures were drawn by him from the type of the species.

Formation and locality.—Middle Cambrian, Georgia Formation. Even-bedded and conglomerate limestone on the ridge east of the city of Troy, New York. A specimen apparently identical with this species, that is labeled from Bic Harbor, is in the collection of the Geological Survey of Canada.

SCENELLA? VARIANS n. sp.

Plate xii, figs. 2, 2*a*.

Shell small, depressed, conical; apex central or subcentral; aperture ovate or broad ovate. Surface of cast smooth.

This little shell is quite abundant in the decomposed arenaceous, magnesian limestone east of Highgate Springs. In form it is Metoptoma-like, and the reference to Scenella is provisional, as nothing is known of the outer surface except that it has a few concentric striæ of growth on an apparently smooth surface. I know of no closely related species from the Middle Cambrian. An undescribed species from the Potsdam sandstone of Wisconsin and *S.? conula* (Monographs, U. S. Geol. Survey, vol. viii, Pal. Eureka Dist., p. 15, pl. ix, fig. 6) are closely allied, but differ in being more elevated, and *S. retusa* is more depressed and probably of a different shell substance.

Formation and locality.—Middle Cambrian, Georgia Formation. About two miles east of Highgate Springs, Vermont; also, at St. Anne, Province of Quebec, Canada; collection of the Canadian Geological Survey.

SCENELLA? CONULA Walcott.

Plate viii, figs. 2, 2*a*.

Scenella? conula Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 15, pl. ix, fig. 6.

Shell small, conical; apex subcentral, apparently with a tendency to bend a little to one of the sides on which there is a very faintly-indicated line running from the apex to the margin. Aperture ovate. Surface smooth to the unaided eye; it shows fine concentric striæ and a few obscure lines of growth when examined by the aid of a strong magnifying glass.

Dimensions.—Greater diameter, 3^{mm}; lesser diameter, 2.25^{mm}; elevation, about 1.75^{mm}.

This is a small Metoptoma-like shell, the generic reference of which is provisional, as it differs from the type of the genus *Scenella reticulata* in not having a carina running from the apex to the margin; the curvature of the apex is not positively known, as its summit is broken off in all the specimens in the collection.

Formation and locality.—Middle Cambrian. In a shaly band of limestone 3,000 feet below the Secret Cañon shale with *Olenellus Gilberti;* also, 500 feet above the great quartzite, on the east slope of Prospect Mountain, Eureka District, Nevada.

Genus STENOTHECA Salter.

Stenotheca Salter. Name proposed 1866; published by Mr. Henry Hicks, 1872. Quart. Jour. Geol. Soc., vol. xxviii, p. 180.

Mr. Hicks does not give a description of the genus, but from the figures of the type species *S. cornucopia* there is little difficulty in identifying *S. rugosa* with it generically.

The genus may be provisionally described as follows:

Shell depressed conical; aperture oval, elliptical or narrow elongate oval; apex eccentric and curved over towards one end of the shell; surface marked by more or less strong undulations and lines of growth.

The rougher surface and the strongly-arched curvature from the beak to the side opposite to which it curves seem to distinguish Stenotheca from the closely related genus Scenella.

When reviewing the fauna of the St. John Formation, contained in the Hartt collections, I referred *Discinia Acadica* of Hartt to the genus Palæacmea, as the material for study was too fragmentary to change the generic reference made by Mr. Whitfield (United States Geological Survey, Bull. 10, p. 19). Subsequently I saw specimens of *Stenotheca rugosa* that showed that, in exterior appearance, *D. Acadica* was a true Stenotheca? (Amer. Jour. Sci., 3d ser., vol. xxix, p. 117, 1885). More recently Mr. G. F. Matthew has published a note on *S. Acadica*, describing the interior, and proposes that it be placed in a subgenus of Stenotheca, "characterized by its subcircular aperture and patelloid form." No name is given for the proposed subgenus (Canadian Rec. Sci., vol. ii, p. 10, 1886.)

STENOTHECA RUGOSA Hall (sp.).

Plate xii, figs. 1, 1*a–e*.

Metoptoma? rugosa Hall, 1847. Pal. N. Y., vol. i, p. 306, pl. lxxxiii, figs. 6*a–c*.
Stenotheca rugosa Billings, 1872. Can. Nat., new ser., vol. vi, p. 479.
Stenotheca pauper Billings, 1872. Can. Nat., new ser., vol. vi, p. 479.

Original description.—"Elliptical, with the sides straight; apex elevated and slightly bent forwards; posterior extremity broader than the anterior; surface marked by strong concentric undulations, which increase in number on the posterior side.

"*Position and locality.*—In the subcrystalline calcareous beds, associated with the Hudson River shales, near Troy."

The usual outline of the aperture is that of an elongate oval, varying somewhat in proportion and the curvature of the sides, so as to be subcircular in some examples. The apex varies in position from a point nearly over the anterior margin to one-third the distance between the anterior and posterior margins. On a young shell, 3^{mm} in length, the apex overhangs the anterior margin. There is considerable variation in the surface markings; the strong annulations of growth seen on some shells are reduced in size and increased in numbers in others, and in the young shells only the fine striæ seen on and between the annulations on the older shells are seen. The annulations also vary from evenly-rounded to sharp, almost imbricating ridges. The entire surface is covered by very fine, somewhat irregular striæ.

Dimensions.—An average sized specimen has a height of 7mm, with a diameter at the aperture of 10mm and 13mm, respectively.

Stenotheca cornucopia Salter (Quart. Jour. Geol. Soc., vol. xxiii, pl. vii) is a more erect, conical shell, but presents relatively the same strong concentric undulations and lines that occur on *S. rugosa*, although a much smaller shell. The shell figured from the Spanish Cambrian is so closely related to *S. rugosa* that, from the figures, it is difficult to find specific distinctions between them. It is not specifically named, but placed under the name of Capulus, undt. In the text the suggestion is made that perhaps it may belong to the genus Metoptoma (Bull. Soc. Géol. de France, t. xvii, p. 531, pl. viii, figs. 3, 3*a*, *b*).

Stenotheca acadica Hartt appears to be a compressed shell that, when compared to flattened, compressed specimens of *S. rugosa*, is generically related to it.

On examining the type of *Stenotheca pauper*, in the collection of the Geological Survey of Canada, I found it to be a coarsely-ribbed variety of *S. rugosa*, such as occurs both at Troy, New York, and Bic Harbor, Canada. A variety occurs at L'Anse au Loup that has much sharper ridges of growth and strong radiating lines, and it is much more elevated and conical than the typical forms of the species found elsewhere, with the exception of a single fragment from Troy, New York.

Formation and localities.—Cambrian, Georgia group. Conglomerate limestone on the ridge east of the city of Troy, New York; Bic Harbor, below Quebec; L'Anse au Loup, on the north side of the Straits of Belle Isle; and at Topsail Head, Conception Bay, Newfoundland.

STENOTHECA ? ELONGATA Walcott.

Plate xii, fig. 4, 4*a*, *b*.

Stenotheca elongata Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 23, pl. ix, figs. 2, 2*a*.

Original description.—"Shell small, elongate, with the apex incurved and depressed nearly to the margin; laterally compressed so as to form a ridge nearly the entire length. Aperture elongate, ovate, somewhat acutely pointed at the end towards which the apex curves, and rounded at the opposite extremity, the greatest width occurring about two-thirds the distance from the narrow end. Surface marked by numerous fine concentric striæ and lines of growth.

"The narrow elongate aperture, depressed apex, and fine lines of growth serve to distinguish this from described species of the genus.

As far as yet known the genus Stenotheca is confined to the Cambrian fauna."

The Nevada specimens correspond so closely with those from L'Anse au Loup that I fail to find good specific characters to distinguish between them. There is a certain irregularity in the form of the aperture that, united with the rounded carina or angular dorsal ridge, suggests a bivalve shell not unlike the young of the common *Mytilus edulis*, but, judging from the material at hand, I think it is only a superficial resemblance.

Formation and localities.—Cambrian. In the passage beds between the typical Middle Cambrian (Georgia) and Upper Cambrian (Potsdam) faunas, Secret Cañon, Eureka Mining District, Nevada. At L'Anse au Loup, on the north side of the Straits of Belle Isle, it is associated with a typical Middle Cambrian fauna that occurs in a hard reddish-colored limestone.

Genus PLATYCERAS Conrad.

Platyceras Conrad, 1840. Ann. Rep. Geol. Surv. New York, p. 205.

The genus Capulus Montfort, 1810 (Conch. Syst., p. 55), appears to include the species under Platyceras, but, until more is known of the American species, we shall follow the example of Hall and Billings, and refer them to Platyceras.

PLATYCERAS PRIMÆVUM Billings.

Plate xii, figs. 5, 5*a*.

Platyceras primævum Billings, 1871. Can. Nat., new ser., vol. vi, p. 220.

Original description.—"Shell minute, consisting of about two whorls, which, as seen from above, are ventricose, but most narrowly rounded at the suture; the inner whorl scarcely elevated above the outer. The under side is not seen in the specimen. Diameter, measured from the outer lip across to the opposite side, one line; width of last whorl at the aperture about one-third of a line."

The Troy specimens correspond closely to the above description, and, as they are associated with the same species as *P. primævum* at Bic, I have little doubt of their specific identity. From the description, the Bic specimen shows the right side. A specimen from Troy is nearly free from the matrix, and proves that the dorsum is nearest the right side and that the left side is more ventricose. The surface is also preserved, and shows fine striæ and lines of growth that arch backward over the dorsum, indicating a deep dorsal sinuosity in the peristome; a second series of fine striæ cross the striæ of growth and form a fine reticulated surface.

Dimensions.—Diameter of cross-section of the outer volution, 3^{mm}; diameter of aperture, 1.75^{mm} and 2.5^{mm}.

Platyceras minutissimum Walcott (Pam. in advance 32d Rep. N. Y. State Mus. Nat. Hist., 1880), from the Upper Cambrian (Potsdam) horizon, is a small shell related to *P. primævum*. It differs in having stronger surface striæ, a more prominent dorsal ridge, and the whorl larger and more prominent.

Formation and locality.—Middle Cambrian, Georgia group. In the conglomerate limestone on the ridge east of the city of Troy, New York, and at Bic Harbor, below Quebec, on the St. Lawrence River, Canada.

PTEROPODA.

It is with considerable reservation that I place the genera Hyolithes and Matthevia under the Pteropoda. The genera Conularia, Hyolithellus, Coleoprion, Coleolus, Hemiceras, Salterella, Pterotheca, Phragmotheca, Matthevia, and perhaps Palænigma form a group that, although representative, in a measure, of the recent Pteropoda, differ in other respects so much that it appears as though a division of the Gasteropoda equivalent to the Pteropoda might be consistently made to receive them.

The following families of this group occur in the Paleozoic:

Hyolithellidæ.	Hyolithes. Hyolithellus. Hemiceras. Coleoprion. Coleolus. Camarotheca. Diplotheca.
Tentaculidæ.	Tentaculites. Styliola.
Conularidæ.	Conularia.
Salterellidæ.	Salterella.
Matthevidæ.	Matthevia. Palænigma ? ?.
Pterothecidæ.	Pterotheca. Phragmotheca.

Genus HYOLITHES Eichwald.

Hyolithes Eichwald, 1840. Sil. schicht. Syst. in Ehstl., p. 97.
Theca Sowerby, 1845; *Pugiunculus* Barrande, 1847; *Vaginella* d'Orbigny, 1850.

Mr. Hall gives a history of this genus and a list of American species placed in it (Pal. N. Y., vol. v, pt. 2, pp. 191–195, 1879). Grouped opposite Potsdam sandstone we find *H. excellens*, a Lower ? Cambrian species from Newfoundland, and the following from the Middle Cambrian, Georgia Formation: *H. Americanus*, *H. communis*, *H. Emmonsi*, *H. impar*, and *H. princeps;* and from the Potsdam sandstone, or Upper Cambrian, *H. gibbosus*, *H. gregarius*, and *H. primordialis*, a total of nine species from the Cambrian System.

Since that publication a number of species have been described, and the American species of the genus *Hyolithes* are distributed as follows, those from above the Potsdam sandstone according to their respective authors and those of the Cambrian in part by the writer:

Hyolithes (Theca) aculeatus Hall.	Lower Carboniferous.
carbonaria Walcott.	
aclis Hall.	Hamilton Formation.
triliratus Hall.	
singulus Hall.	
striatus Hall.	
ligea Hall.	Upper Helderberg Formation.
principalis Hall.	
centennialis Barrett	Lower Helderberg Formation.
parviusculus Hall	Hudson River Formation.
Vanuxemi Walcott	Lower Silurian (Ordovician).
gibbosus H. & W.	Upper Cambrian. Potsdam Sandstone.
primordialis Hall, (=gregarius.)	
Americanus Billings	Middle Cambrian. Georgia Formation.
Billingsi Walcott.	
communis Billings.	
var. Emmonsi Ford.	
impar Ford.	
princeps Billings.	
Shaleri Walcott.	Lower Cambrian. Braintree Argillites.
excellens Billings.	Lower Cambrian. Newfoundland.
(Camarotheca) Daniana Matthew.	Lower Cambrian. St. John Series.
gracilis Matthew.	
Micmac Matthew.	
(Diplotheca) Acadica Hartt.	
var. obtusa Matthew.	
var. crassa Matthew.	
var. sericea Matthew.	
Hyattiana Matthew.	
var. caudata Matthew.	

In the description of the species the flattened side, with the projecting margin, is considered the dorsal side and the rounded side the ventral. This is the reverse of that used by Mr. Billings, Professor Hall, and heretofore by the writer; but a comparison with the shells of the recent genus Cleodora shows the projecting side to be the dorsal. This view was held by Morris and Sowerby in the description of the genus Theca, and by Salter in the description of species (Mem. Geol. Surv. Great Brit., vol. iii).

HYOLITHES AMERICANUS Billings.

Plate xiii, figs. 6, 6*a–f*.

Theca ? triangularis Hall, 1847. Pal. N. Y., vol. i, p. 313, pl. lxxxvii, figs. 1*a–d*.
Theca triangularis Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33.
Hyolithes Americanus Billings, 1872. Can. Nat., 2d ser., vol. vi, p. 215, figs. 2*a*, *b*, p. 213; Amer. Jour. Sci., 3d ser., vol. iii, p. 353, figs. 2*a*, *b*.

Original description (*Hall*).—"Bodies of a slender pyramidal form, flat behind and rounded at the larger extremity, angular in front; small extremity pointed; section (aperture?) triangular. The surface shows no defined markings, though the outer covering is not preserved in the specimens which I have seen."

Mr. Billings's description.—"*H. Americanus*.—Length from twelve to eighteen lines, tapering at the rate of about four lines to the inch. Section triangular, the three sides flat, slightly convex or slightly concave, the dorsal [ventral] and lateral edges either quite sharp or acutely rounded. Lower [upper] lip rounded, projecting about two lines in full-grown individuals. Surface finely striated, the striæ curving forwards on the ventral [dorsal] side, and passing upwards on the sides at nearly a right angle, curve slightly backwards on the dorsum [ventrum]. In a specimen eighteen lines in length the width of the aperture is about six lines and the depth about four, the proportion being slightly variable.

"The operculum has a very well-defined conical ventral [dorsal] limb, the apex of which is situated above the center, or nearer the dorsal [ventral] than the ventral [dorsal] side. The dorsal [ventral] limb forms a flat margin, and is so situated that when the operculum is in place the plane of this flat border must be nearly at right angles to the longitudinal axis of the shell. In an operculum six lines wide the height of the lower limb to the apex of the cone is two and a half lines, and the width of the flat border, which constitutes the dorsal [ventral] limb, about one line.

"This species occurs at Bic and St. Simon; also, at Troy, New York, where it has been found abundantly by Mr. S. W. Ford, of that city. It is *Theca triangularis* of Hall (Pal. N. Y., vol. i, p. 313, 1847). As that name was preoccupied by a species previously described by Colonel Portlock (Geol. Rep. on Londonderry, p. 375, pl. 28 A, figs. *3a*, *3b*, *3c*, 1843), it must be changed. It is a very abundant species and varies a good deal."

The small shell figured on plate xiii, fig. 6*f*, is broader at the aperture than the typical form, but fig. 6 is intermediate, and other specimens still more closely unite the two extremes. This same range of variation is observed in the common species of the Potsdam sandstone of Wisconsin, *H. primordialis*. The operculæ of the two species are also of the same type, and when we compare the shells of *H. Americanus*, with a rounded ventral angle, with the specimens of *H. primordialis*, having a high ventral angle, the two species approach each other quite closely, the latter species being the representative in the Upper Cambrian of the former species in the Middle Cambrian.

There is a considerable range of variation in the angle of divergence of the sides, and also the angles formed by the union of the three sides. This species is quite abundant at Troy, although finely-preserved specimens are rare.

Formation and localities.—Middle Cambrian. Conglomerate limestone on the ridge east of Troy, New York, and in a similar formation at Bic and St. Simon, Canada.

HYOLITHES BILLINGSI n. sp.

Plate xiii, figs. 1, 1*a–d*.

Salterella obtusa Billings, 1861. Geology of Vermont, vol. ii, p. 955. *Idem*, 1865. Pal. Foss., vol. i, p. 18.
Hyolithes primordialis? White, 1874. Geog. and Geol. Expl. & Surv. West 100th Merid. Prelim. Rep. Invert. Foss., p. 6, and vol. iv, pt. 1, p. 37, pl. i, figs. 5*a–e*.
Not *Theca obtusa* Salter, 1866. Mem. Geol. Surv. Great Britain, vol. iii, p. 352.

Original description.—"From six to eight lines in length; diameter at aperture about three lines. The transverse section is always subtriangular, and in some of the specimens one side appears to be flat like a *Theca*, and I would refer it to that genus, only that the tube is composed of successive layers. None of the specimens are perfect, but the form is sufficiently different from that of the other two to indicate a distinct species."

When breaking up a piece of rock holding *Salterella pulchella* from L'Anse au Loup, I found several specimens of this species corresponding to the above description, and, not being able to separate them from typical forms of the genus Hyolithes and as several species have two or three layers of shell, I refer the species to that genus. The shell is very thick and strong in the specimens identified with *H. obtusa* from Nevada.

The Nevada shell agrees in every respect with those from L'Anse au Loup. The operculum associated with it appears to be identical with that of *H. Americanus*, except in the more rounded ventral angle. *H. Billingsi* appears, in many examples, to be very closely related to the smoother shells of *H. Americanus*, and I am strongly inclined to consider it little more than a variety of that species. It is, in fact, a form intermediate between the latter and *H. primordialis*, and, if the three forms had been found in the same layer of rock, I should be inclined to unite them in one species; but, as they are from widely separated localities and *H. primordialis* associated with a different and later fauna, it appears best, until the three are found associated, to consider them as distinct.

As the specific name was preoccupied by Salter's *H. obtusa*, I propose *H. Billingsi*, in honor of the original discoverer of the species.

Formation and localities.—Middle Cambrian. L'Anse au Loup, Labrador, on the north side of the Straits of Belle Isle, in a hard reddish limestone; at Pioche, Nevada, it is associated with *Olenellus Gilberti*, &c., in a gray granular limestone. In the Highland Range it occurs in the shales above the *Olenellus* shale; and one mile below Argenta, Big Cottonwood Cañon, Utah, it is abundant in a silico-argillaceous shale. The specimens in the shale are compressed, but they appear to be identical with those from Pioche, Nevada.

HYOLITHES PRINCEPS Billings.

Plate xiii, figs. 5, 5*a*, *b*.

Hyolithes princeps Billings, 1872. Can. Nat., new ser., vol. vi, p. 216, figs. 4*a*, *b*, of p. 213.

Original description.—"Shell large, sometimes attaining a length of three or four inches, tapering at the rate of about three lines to the inch. In perfectly symmetrical specimens, the transverse section is nearly a semicircle, the ventral [dorsal] side being almost flat, usually with a slight convexity, and the sides and the dorsum [ventrum] uniformly rounded. In many of the individuals, however, one side is more abruptly rounded than the other, in consequence of which the median line of the dorsum [ventrum] is not directly over that of the ventral [dorsal] side, and the specimen seems distorted. This is not the result of pressure, but is the original form of the shell. Sometimes, also, there is a rounded groove along the median line of the dorsum [ventrum]. The latter is somewhat more narrowly rounded than the sides. Lower [upper] lip uniformly convex and projecting about three lines in a large specimen. Surface with fine striæ and small subimbricating ridges of growth. These curve forward on the ventral [dorsal] side. In passing upwards on the sides, they at first slope backwards from the ventral [dorsal] edge, and then turn upwards and pass over the dorsum [ventrum] at a right angle to the length.

"When the width of the aperture is seven lines, the depth is about five. The operculum has not been identified."

With the exception of referring to the convex side as the dorsal and the flattened side as the ventral, I will not attempt to add to the above description.

Hyolithes excellens Billings (Can. Nat., new ser., vol. vi, p. 471) is a very closely related species; the differences are in the greater apical; angle of *H. excellens*, 22°, and the rounded lateral angles, those of *H. princeps* being quite sharp and the apical angle 15°.

The smaller shells of *H. princeps* are much like those of *H. Americanus*, the principal difference being in the sharper ventral angle of *H. Americanus*.

This is the largest species of Hyolithes known, *H. elegans* Barrande (Syst. Sil. Bohême, vol. iii, pls. xi and xv) and a few other species alone equaling it in size.

The specimens of this species from Silver Peak are identical in form with those from Canada and occur in a limestone containing *Olenellus Gilberti*, Kutorgina like *K. cingulata*, and several species of sponges—Ethmophyllum, &c.

Formation and localities.—Middle Cambrian. In the conglomerate limestones of St. Simon and Bic Harbor, below Quebec, on the St. Lawrence River; also, on Silver Peak, Nevada, long. 117° 20′ W., lat. 38° N.

HYOLITHES COMMUNIS Billings.

Plate xiv, figs. 3, 3*a–e*.

Hyolithes communis Billings, 1872. Can. Nat., new ser., vol. vi, p. 214, figs. 1*a*, *b*, of p. 213.

Compare *H. impar* Ford.

Original description.—"This species attains a length of about eighteen lines, although the majority of the specimens are from ten to fifteen lines in length. The ventral [dorsal] side is flat (or only slightly convex) for about two-thirds the width, and then rounded up to the sides. The latter are uniformly convex. The dorsum [ventrum], although depressed convex, is never distinctly flattened, as is the ventral [dorsal] side. The lower lip projects forward for a distance equal to about one-fourth or one-third the depth of the shell. In a specimen whose width is three lines the depth is two lines and a half.

"The operculum is nearly circular, gently but irregularly convex externally and concave within. The ventral [dorsal] limb is seen on the outside as an obscurely triangular, slightly-elevated space, the apex of the triangle being situated nearly in the center of the operculum. The base of the triangle forms the ventral [dorsal] margin. This limb occupies about one-third of the whole superficies of the external surface. The remainder, constituting the dorsal [ventral] limb, is nearly flat, slightly elevated from the margin towards the center. On each side of the apex of the ventral [dorsal] limb there is a slight depression running from the nucleus out to the edge. On the inside there is an obscure ridge corresponding to each one of the external depressions. It is most prominent where it reaches the edge. These two ridges meet at the center and divide the whole of the inner surface of the operculum into two nearly equal proportions.

"The surface of the operculum is concentrically striated. The shell itself in some of the specimens is covered with fine longitudinal striæ, from five to ten in the width of a line. The shell varies in thickness in different individuals. In some it is thin and composed of a single layer, but in others it is much thickened by concentric laminæ, and thus approaches the structure of a *Salterella*. There are also fine engirdling striæ, and sometimes obscure subimbricating rings of growth."

With the exception of reversing the use of the terms ventral and dorsal, little can be added to the above very complete description of the Canadian specimens, but those from Troy, New York, show that the shell was partitioned off by imperforate septa near the apex, in the same manner as *H. impar* and *H. communis* var. *Emmonsi*.

H. Emmonsi Ford is very closely related to this species, and, I think, not more than a variety of it, as the characteristic depression on the flattened face of *H. Emmonsi* is slightly shown on a specimen of *H. communis*, and other specimens still further unite them.

Formation and localities.—Middle Cambrian. In conglomerate limestones of St. Simon and Bic Harbor below Quebec, on the St. Lawrence River, Canada; also, in the even-bedded and conglomerate limestones on the ridge east of Troy, New York.

HYOLITHES COMMUNIS var. EMMONSI Ford.

Plate xiv, figs. 4, 4*a*, *b*.

Salterella Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33.
Hyolithes Emmonsi Ford, 1873. Amer. Jour. Sci., 3d ser., vol. v, p. 214, figs. 3*a–c*.

Original description.—"Shell elongate, slender; apex neatly pointed, transverse section subtriangular; sides gently rounded and meeting to form a tolerably prominent though often scarcely perceptible dorsal [ventral] ridge in the forward part of the shell, which quickly dies down, so that a transverse section taken near the apex would be almost a semicircle. Ventral [dorsal] side flattened, with a wide, shallow depression along the middle, which runs the whole length of the shell; lateral edges rounded up to the sides. The most projecting point of the lateral walls occurs close to the ventral [dorsal] side. When the width is 0.24 of an inch the depth is 0.18 of an inch. The walls of the shell are thick and appear to be made up in some instances of successive layers of laminæ. The surface is ornamented with very fine concentric striæ, which run directly around the shell or at right angles to its longitudinal axis. The tubes sometimes attain a length of 2 inches, even when imperfect, but the majority of the specimens in my possession are less than an inch in length.

"The operculum has the same contour as a transverse section of the shell taken at about the mid-length, and is, accordingly, distinctly emarginate at the middle of the border of the ventral [dorsal] limb The ventral [dorsal] limb itself is in the main flat, or nearly so, and embraces not far from two-thirds of the whole superficies of the operculum. Through the middle of it, beginning at the emargination, runs a low, rounded, conical elevation having the apex directed toward the dorsal [ventral] limb and slightly encroaching upon it. The dorsal [ventral] limb, unlike the ventral [dorsal], is highly convex, except a narrow space near the margin, which is flat. A narrow groove, extending from the apex of the cone just mentioned, or nucleus of the operculum, to the margin, occupies the central portion of this limb and divides it into two equal parts. (A similar division is frequently well shown in the opercula of adult specimens of *Hyolithes Americanus*.) A portion of the operculum about the nucleus, of a triangular shape, is sometimes more elevated than the rest of the surface, and appears like a little plate added for strength. The surface is covered with fine, thread-like, concentric striæ.

"In the slender form of the shell, the direction of the surface lines of the same, and the internal thickening already noticed, this species approaches closely the structure of a *Salterella*. Especially is this true when the specimens are quite small, as is usually the case; and in an earlier communication (this Journal for July, 1871), published prior to the discovery of specimens of its operculum, the species was referred by me to that genus. It may be readily distinguished from either of the species of *Hyolithes* found with it by the direction of the surface lines of the shell and its distinctly hollowed dorsal side."

To Mr. Ford's excellent description of this species it may be added that when we find a specimen of *H. impar* with an unusually flattened dorsal side it approaches very closely in form to the more rounded shells of *H. Emmonsi*, in which the dorsal depression is very slight.

Another character observed is one that occurs in *H. communis* and *H. impar*. It is the presence of a transverse diaphragm in the tube towards the apex. This appears to have caused the shell to become deciduous in many instances, and we now find numerous examples showing the blunt terminal portion. Some shells show the rounded smooth end without any constriction; others have a narrow concentric constriction just within the termination. The cast of the surface of the septum shows a slight central cicatrix or scar, but no evidence of a perforation in the septum could be observed. The average size of the tube at the point of decollation is 1^{mm}. The largest seen is 1.5^{mm} and the smallest $.75^{mm}$. When studying the septum, the close similarity between it and the first septum of the species of Orthoceras and Cytoceras, as figured by Barrande (Céphalopodes, Études générales, 1877, pls. 487, 488), was at once brought to mind, and also the interesting question of the relations of these shells to the Cephalopoda.

A paper has been lately received from Mr. G. F. Matthew, in which he states that several of the Hyolithes from the base of the St. John group have distinct septa at the base of the tube. The genus and species are not mentioned (Nat. Hist. Soc. N. B., Bull. 10, p. 102, 1885) In the American Journal of Science, vol. xxx, p. 293, 1885, Mr. Matthew describes the genus Diplotheca.

Mr. Matthew quotes, in the former paper, from a letter written by Mr. Alpheus Hyatt, where the latter says: "These fossils, with their distinct septa, are startlingly similar to certain forms of Nautiloidea, but there is no siphon. They, however, confirm Von Jhernig's and my opinion that the Orthoceratites and Pteropods have had a common, but as yet undiscovered, ancestor in ancient times."

Mr. Ford speaks of the thick shell, and that it is apparently made up of successive layers of laminæ. Several specimens in the Survey collections show this feature. The shell is formed of three or more layers: first, a thin outer layer, with rather strong even striæ that cross the flattened ventral face nearly direct and arch forward on the dorsal face, the flattened side in this species being the ventral face and not the dorsal, as in most species; the second layer appears to be of a smooth, even character, much like a filling between the outer and inner shell; the inner shell is thin and concentrically striated in a slightly different manner from the outer shell; a fourth layer appears to exist in one example, but it is too obscure for study.

I find associated with the typical forms of Mr. Ford's *H. Emmonsi* shells that form a gradation between them and *H. communis*. The slightly convex dorsal side becomes flat and then slightly raised, as in *H. communis*. With a series of specimens, it is difficult to determine specific differences between them. Following the series towards the more rounded forms, we find that *H. impar* is readily reached. *H. communis* appears to be the central portion of a series uniting *H. impar* and *H. Emmonsi*. The most decided point of difference between *H. communis* and *H. Emmonsi* is the apical angle, that of *H. communis* being about 13° and that of *H. Emmonsi* about 8°. The two specimens I have before me of *H. communis* from Bic show only concentric striæ, as in *H. Emmonsi*.

H. communis var. *Emmonsi* is associated with *H. Americanus*, *H. communis*, *H. impar*, *Hyolithellus micans*, *Stenotheca rugosa*, &c.

The cross section of the tube is much like that of *H. teres* Barrande (Syst. Sil. Bohême, vol. iii, pl. x, fig. 4), except in the slightly convex ventral face.

Formation and locality.—Middle Cambrian. Even-bedded and conglomerate limestone on the ridge east of the city of Troy, New York.

Hyolithes impar Ford.

Plate xiv, figs. 1, 1*a–e*.

Hyolithes impar Ford, 1872. Amer. Jour. Sci., 3d ser., vol. iii, p. 419, figs. 1*a*, *b*, 2*a*, *b*.

Original description.—"The shells of this species are plump, elongate bodies, tapering to an acute point. The largest specimen obtained would, if perfect, be 1¾ inches in length. The usual length, however, is about 1¼ inches. The section is generally broadly and regularly oval, but in some specimens is rather more flattened on the ventral [dorsal] side than in the diagram of the one below given. Some specimens show a tendency to become keeled along the dorsum [ventrum], but this feature is rare and not well defined in any case. In an imperfect specimen 1.14 inches in length the rate of tapering on the ventral [dorsal] side is .10 of an inch in a distance of .60 of an inch. The width of the tube at the aperture is .32 and the depth .26 of an inch. In this specimen the lower [upper] lip projects beyond the limit of the dorsum [ventrum] .14 of an inch. The surface is ornamented with fine engirdling lines, which upon the ventral [dorsal] side curve gently forward, thence more sharply backward upon the sides until they reach a point at about the middle of the depth, where they are again deflected, and flow across the dorsum [ventrum] in uninterrupted, slightly forward-bending curves. There are also prominent subimbricating lines of growth, which give to some of the specimens an exceedingly rugose aspect.

"The operculum is of an oval form, irregularly convex externally, and for the most part concave within. The nucleus is situated at the center, and in perfect specimens is vertical and acute. On either side of the nucleus, in the line of the longer diameter, there exists a conspicuous groove, which gradually widens in passing from the center out to the edge. With the exception of the nucleus, which barely separates them, these grooves divide the operculum externally into two equal parts. These are, respectively, the dorsal and ventral limbs. The ventral [dorsal] limb is smooth on the outside or broken only by concentric lines. Its convexity is greatest at the nucleus. The dorsal [ventral] limb has nearly, sometimes quite, the same degree of convexity, but may be readily distinguished from the ventral [dorsal] by the presence of two obscure ridges radiating from the nucleus to the margin and inclosing a triangular space along the central portion of the limb. The two limbs are so situated relatively to each other as to give to the base of the operculum a curvature equal to that indicated by the form of the aperture of the shell. In the interior of the operculum there is a little pit directly beneath the nucleus. From this point radiate two strong wedge-shaped ridges corresponding to the exterior grooves. There are also two ridges of similar form running from the same point to the margin of the dorsal limb, lying beneath and included within the limits of of the triangular space seen on the outside of that limb. All of these ridges are widest at their junction with the margin. They severally terminate in the central pit and divide the interior into four unequal parts.

"The surface of the operculum is covered with fine concentric striæ, from 8 to 10 in the space of .06 of an inch. Along with these there sometimes occur coarser lines of growth. The interior is both radiately and concentrically striated. The concentric lines are mostly coarser, fewer in number, and far less regularly disposed than those on the outside. The radiating lines are very numerous, and with the concentric lines give to the interior a singularly reticulated appearance under the magnifier. They are barely visible to the naked eye.

"This is a well marked species and offers but little variation of form. It is closely related to *Hyolithes communis* Billings (Can. Nat., vol. vi, p. 214, December, 1871), but is nevertheless quite distinct therefrom. In *H. communis*, according to Mr. Billings, the shell is sometimes longitudinally striated, which is not the case, so far as observed, in the shells of this species. The operculæ are also different. In the operculum of *H. communis* there are but two ridges in the interior. These correspond to the longitudinal ridges of our species as shown in figure 2*b*. There is also a slight variation in the rate of tapering of the two species. They are, therefore, entirely different. A species of about the same size and form occurs in the Potsdam sandstone of Wisconsin (16th Reg. Rep., p. 135*, pl. vi, figs. 30 and 31)."

The species last referred to by Mr. Ford has a similar apical angle, but the cross section and the operculum are quite different. I also suspect that a comparison of specimens with *H. communis* Billings will show much closer relations than noted above.

One peculiarity of this species is the strong, thick shell. In a tube 5^{mm} in diameter the shell is 1^{mm} thick. In a shell of *H. Americanus* of the same size, it is not more than $.5^{mm}$ in thickness. The shell appears to be made up of an inner and outer layer, with a space between of irregular width, which is filled in with a layer of mineral matter not unlike the thin inner and outer layers of shells; the effect is that of an inner and an outer shell that did not fit exactly, with the interspace filled with foreign matter.

The shell of *H. Emmonsi* appears to be of the same character, and *H. impar* has imperforate septa towards the apex of the shell similar to those of *H. Emmonsi.*

Three of the figures illustrating this species were drawn by Mr. Ford from the type specimens in his collection.

The section of *H. cinctus* Barrande (Syst. Sil. Bohême, vol. iii, pl. ix, fig. 11) is much like that of *H. impar*. Usually specimens of this genus are so crushed and flattened that it is difficult to institute comparisons between the species preserved in slates and shales and those imbedded in limestone.

Formation and locality.—Cambrian, Georgia Group. Conglomerate and even-bedded limestone on the ridge east of the city of Troy, New York.

HYOLITHES sp. undet.

In the "Red sandrock" of Vermont, a species of Hyolithes occurs that, in its apical angle, 15°, and the outline of its cross-section, resembles *H. primordialis* of the Potsdam sandstone. The material is so poorly preserved and the species of the genus so often are closely related in certain characters, while differing in others, that I hesitate in identifying it with any described form, and, for the present, prefer to indicate only the presence of the genus at that horizon.

Formation and localities.—Middle Cambrian, Georgia Formation. About one mile east of Highgate Springs, in a reddish-colored, decomposed, arenaceous, magnesian limestone; also, in a purplish sandstone above the Olenellus bed east of Swanton, Vermont.

At the Highgate locality, *Olenellus Thompsoni* and *Ptychoparia Adamsi* occur in the same layer of rock.

Genus HYOLITHELLUS Billings.

Hyolithellus Billings, 1872. Can. Nat., new. ser., vol. vi, p. 240.
Discinella Hall, 1873. Twenty-third Rep. N. Y. State Mus. Nat. Hist., p. 246.

Original description.—"Since the sheet containing the description of *Hyolithes micans* was printed off, I have arrived at the conclusion that a new genus for its reception should be instituted. I propose to call it

Hyolithellus. It differs from *Hyolithes* in its long, slender form and in the peculiar structure of its operculum."

Hyolithellus, in the slender, elongate form of its shell, appears to represent the forms referred to Coleolus and Coleoprion from the Upper Silurian and Devonian, but the peculiar operculum associated with it is so distinctive that it is readily distinguished from them and also from the more cylindrical species of Hyolithes.

The description of Mr. Hall's genus Discinella is that of the operculum of this species, and as the type material is from the Troy beds there can be little doubt of the identification.

The following is the original description of Discinella:

"In the limestone beds accompanying the shales of the Quebec Group near Troy there is a minute discinoid phosphatic shell which I have long known in its exterior character as having the concentrically-striated and obscurely-radiate surface, with an eccentric apex, like many of the Discinæ. The interior of the shell (dorsal valve) is distinctly marked by nine radiating depressions, the central one of which extends toward the margin nearest the apex, with four others upon each side. At the extremities of some of these depressions there are distinct muscular markings; but were all these to be considered due to the muscular organization we would scarcely recognize the fossil as a Brachiopod, but rather as a Gasteropod. The general character of shell, however, is such as to ally it with the Discinidæ, and, since we do not yet know any Gasteropod of similar form and character in the older rocks, I propose for this fossil the name of *Discinella*."

As there is but one species referred to Hyolithellus, the generic and specific characters are given in the description of that species.

HYOLITHELLUS MICANS Billings.

Plate xiv, figs. 2, 2*a–e*.

Hyolithes micans Billings, 1872. Can. Nat., 2d ser., vol. vi, p. 215, figs. 3*a*, *b*, of p. 213.

Original description.—"This is a long, slender, cylindrical species, with a nearly circular section. The rate of tapering is so small that it amounts to scarcely half a line in [a] length of eighteen lines, where the width of the tube is from 1 to 2 lines. The largest specimen collected is 2½ lines wide at the larger extremity, and if perfect would be 4 or 5 inches in length.

"The operculum does not show distinctly a division into a dorsal and ventral limb. It is of an ovate form, depth somewhat greater than the width, the nucleus about one-third the depth from the dorsal margin. Externally it is gently concave in the ventral two-thirds of the surface; a space around the nucleus is convex and finely striated concentrically. On the inner surface there is a small pit at the dorsal third of the depth, indicating the position of the nucleus. From this point radiate ten elongate ovate scars, arranged in the form of a star, the rays towards the ventral side being the longest. None of these scars quite reach the margin.

"The shell and operculum are thin and of a finely lamellar structure, smooth and shining.

"Occurs at Bic and St. Simon; also, at Troy, New York.

"Collectors, T. C. Weston and S. W. Ford.

"Sometimes numerous small specimens from ½ a line to 3 lines in length are found with the operculum on the same slab.

"This shell appears to me at present to constitute a new genus, differing from the majority of the species of *Hyolithes* in its circular section, the operculum not divided into dorsal and ventral lines, and in the remarkable system of muscular impressions on the interior. Barrande has figured an operculum of the same type, differing from this in having only three instead of five pairs of impressions. They are, however, arranged on the same plan in both the Canadian and Bohemian species. It is possible that our species may be a *Salterella*."

From material in the collections of the United States Geological Survey, I find that the outer surface of the shell, although apparently smooth in many specimens, is also marked by concentric striæ of growth that in some examples are quite strong and regular in arrangement. The scars on the operculum also show lines of growth. The shell, for the first 10^{mm} or 15^{mm}, is often curved and almost twisted in some examples. All the larger portions seen are straight.

The cross section is circular or broad-ovate, as is seen by comparing the outline of different examples of the opercula.

Why Mr. Billings suggested the possibility that this species might be a Salterella I cannot tell, as it appears to have nothing in common with it except a circular or ovate cross section.

Formation and localities.—Middle Cambrian, Georgia Formation. Conglomerate limestone at Bic and St. Simon, Canada, and Troy, New York.

A species of Hyolithellus, apparently a large *H. micans*, occurs with the Middle Cambrian fauna, in the silico-argillaceous shales, one mile below Argenta, Big Cottonwood Cañon, Utah.

Genus SALTERELLA Billings.

Salterella Billings, 1861. Geology of Vermont, vol. ii, p. 954. *Idem*, 1865. Pal. Foss., vol. i, p. 17.

Original description.—"Small, slender, elongate, conical tubes, consisting of several hollow cones placed one within another, the last one forming the chamber of habitation of the animal. The cross section of these tubes is circular or subtriangular, and they are either straight or gently curved; the surface is concentrically or longitudinally striated.

"I think these fossils, although no doubt allied to *Serpulites*, sufficiently different therefrom to constitute a distinct genus. Their structure is so compact that they are seldom found compressed, while all species of *Serpulites* are almost invariably in that condition, showing that they consist in general of something more like a membraneous sack than a hard-shelled tube."

The shell of the species of this genus is strong and comparatively thick, much more like those of Tentaculites than Serpulites, and I am inclined to agree with M. Barrande that the relations of the genus are with Tentaculites and Hyolithes (Sys. Sil. Bohême, vol. iii, p. 138, 1867).

The three species described by Mr. Billings, *S. rugosa*, *S. pulchella*, and *S. obtusa*, are from the Middle Cambrian, Georgia Group, on the north side of the Straits of Belle Isle, the two latter species occurring in the same hard specimens of rock.

Salterella obtusa proves to be a species of Hyolithes and is removed to that genus.

Salterella Billingsi Safford (Geology of Tennessee, p. 289, 1869) is from the Trenton Group. Until more is known of the genus I would place this species under it with a query.

SALTERELLA PULCHELLA Billings.

Plate xiii, figs. 3, 3*a*, pl. viii, 7, 7*a–c*.

Salterella pulchella, Billings, 1861. Geology of Vermont, vol. ii, p. 955. *Idem*, 1865. Pal. Foss., vol. i, p. 18.

Original description.—"Elongate, conical, gently curved, from six to eight lines in length and from one line to one and a half in width at the aperture. Surface ornamented with small encircling striæ just visible to the naked eye.

"This species is larger than *S. rugosa*, always a little curved, not so abundant, and when weathered does not present the sharp imbricating annulations of that species."

The species in the Winooski marble is observed only on the polished sections, and it is very difficult to determine its specific characters. It appears to have a smooth outer surface, as no annulations are shown in the longitudinal sections. In form it varies from the description of *S. pulchella*, in being shorter and larger at the aperture; but, as we find numerous examples of a form that corresponds to *S. pulchella* 300 feet higher in the section, associated with the casts of shorter, stouter shells, and also forms that appear intermediate between the slender and stouter examples, it is probable that all belong to one species. In all the specimens yet obtained but a single shell or sheath is shown. This may be owing to the fact that in those from the Winooski marble the separate shells may have disappeared in the semi-crystallization to which the calcite replacing them has been subjected, and all the specimens from the gray and reddish magnesian limestones are in the form of casts of the interior and exterior surface or else showing only the outer surface.

Salterella pulchella was first announced as occurring in the Georgia Group of Vermont by Mr. Billings (Can. Nat., 2d ser., vol. vi, p. 351, 1871), who identified it in fragments of the Winooski marble from Swanton, Vermont, sent to him by Mr. Solon M. Allis, of Burlington, Vermont.

Dr. A. R. C. Selwyn, Director of the Geological Survey of Canada, found a weathered specimen in the conglomerate limestone of Point Levis that shows a cluster of the tubes of this species in a beautiful state of preservation. Dr. Selwyn kindly gave me permission to use the specimen for study and illustration. Several of the shells show, in cross sections, three tubes or cones, one within the other, the walls of the inner cones blending at the larger end with the general wall of the shell. The occurrence of this species at Point Levis does not indicate that it belongs to the Upper Cambrian (Potsdam) fauna or to the Calciferous fauna of the shales in which the pebbles holding it are imbedded, as the pebbles are rolled and worn and are a part of the detrital matter making up the Point Levis strata and were derived from pre-existing rocks, as are also the pebbles and bowlders carrying the Potsdam and Calciferous faunas.

Formation and localities.—Middle Cambrian, Georgia Formation. L'Anse au Loup, Labrador, on the north side of the Straits of Belle Isle, and in conglomerate limestone of Point Levis, opposite Quebec, Canada.

In Vermont, the form referred provisionally to this species ranges through about 500 feet of the mangnesian limestones of the upper portion of the limestone belt, and is best observed in the so-called "Red sandrock" beneath the argillaceous shales, in association with *Ptychoparia Adamsi*, *Olenellus Thompsoni*, &c., east of Highgate Springs, and Swanton, Franklin County, Vermont.

SALTERELLA RUGOSA Billings.

Plate xiii, fig. 2.

Salterella rugosa Billings, 1861. Geology of Vermont, vol. ii, p. 954, fig. 362. *Idem*, 1865. Pal. Foss., vol. i, p. 17, fig. 22.

Original description.—"This little species is straight, conical, tapering uniformly to an acute point. Length from two to four lines, the greater number of the specimens being under three lines; diameter at the larger extremity, one line in a specimen four lines in length; the smaller ones are often a little more obtuse. Aperture circular, equal to about three-fourths the whole diameter. It is not certain that in any of the specimens observed the surface is preserved; they all appear to be divested of the outer covering and exhibit from four to six imbricating sharp annulations in the length of one line, the edges towards the larger end. These are doubtless the exposed edges of the several sheaths of which the tube is composed. They are usually straight, but some are slightly curved."

This is the most marked species of the genus yet described. As far as known to me it has not been discovered except at the typical locality.

Formation and locality.—Middle Cambrian, Georgia Formation. L'Anse au Loup, Labrador, on the north side of the Straits of Belle Isle.

CRUSTACEA.

Genus LEPERDITIA Rouault.

Leperditia Rouault, 1851. Bull. Soc. Géol. de France, 2e sér., t. 8, p. 377. Type *L. Britannica.* Same bulletin, p. 378, figs. 1–3.

LEPERDITIA TROYENSIS Ford.

Plate xvi, fig. 5.

Leperditia Troyensis Ford, 1873. Amer. Jour. Sci., 3d ser., vol. vi, p. 138.

Original description.—"The following description is based upon a single right valve, the only specimen of this species that I have seen.

"*Description:* Minute, obscurely pentagonal in outline, greatly narrowed in front, broad behind, narrowed at either extremity, posterior one somewhat obtusely angular. Dorsal margin straight, ventral margin gently rounded. Surface depressed convex, convexity greatest at little behind the mid-length. Eye-tubercle prominent. Marginal rim well defined all around except at the hinge. A distinct marginal groove can be traced entirely around the carapace, but it is very faint in the upper portion. It is most distinct along the forward half of the ventral outline. Surface smooth and polished.

"Length, 0.18 of an inch; breadth, 0.12 of an inch. Occurs in even-bedded limestone of the Lower Potsdam at Troy. Collected by the writer.

"The characters of this species agree very closely with those of *Leperditia Solvensis* Jones (Annals and Magazine of Natural History, 2d ser., vol. xvii, Feb., 1856, p. 95), from the Menevian group of Wales; but our species is larger, a little different in shape, and provided with a distinct eye-tubercle. They appear, however, to be very nearly related."

The only specimen known to me of this species is in the collection of Mr. Ford, and I am indebted to him for the illustration.

Formation and locality.—Middle Cambrian. Conglomerate limestone on the ridge east of the city of Troy, New York.

LEPERDITIA? ARGENTA n. sp.

Plate viii, fig. 5.

Carapace large; dorsal margin nearly straight; dorsal angles produced into acute elongate points; anterior and posterior ends oblique to the dorsal margin above and rounding into the broadly-rounded ventral margin below; anterior end slightly narrower than the posterior.

Length, 56mm; height, 31mm. The length and height are probably slightly increased by the flattening of the shell by compression.

Surface markings, if any, unknown. This large specimen was found associated with characteristic Middle Cambrian fossils, in the silico-argillaceous, shaly beds resting on the great quartzitic series of the Big Cottonwood Cambrian section. The carapace is flattened between the laminæ of the shale, and only a slight rim around the ventral, anterior, and posterior margins indicates any original irregularities of the surface. The unusual feature is the presence of the spinous dorsal angles. A tendency to an almost spinous angle is seen in some of the Silurian species of Leperditia. This is the largest species now known to me from the Cambrian System. Several species occur at the Potsdam or Upper Cambrian horizon that will be described with that fauna.

It may be that the reference to Leperditia is incorrect, but, with the evidence at hand, it appears to be required. The form suggests at first a reference to the carapace of a phyllopod crustacea allied to Hymenocaris or Protocaris, but the straight dorsal margin and acute dorso-lateral angles are very much against this view.

Formation and locality.—Middle Cambrian. One mile below Argenta, in Big Cottonwood Cañon, Wasatch Mountains, Utah.

Genus PROTOCARIS Walcott.

Protocaris Walcott, 1884. Bull. U. S. Geol. Survey, No. 10, p. 50. (Dated 1884, but not generally distributed until 1885.)

Carapace without evidence of a dorsal suture, rounded on the dorsal line, and bent downward on the sides; without any rostrum. Body many-jointed, 31 segments extending out from beneath the carapace, the last segment broader than the preceding and terminating in two spines. Type, *Protocaris Marshi.*

In comparing Protocaris (*P. Marshi*) with Hymenocaris (*H. vermicauda* Salter, 1852, Brit. Assoc. Rep., pt. 2, Notices and Abstracts, p. 58; Mem. Geol. Surv. Great Brit., vol. iii, p. 293, plate ii, figs. 1–4; plate v, fig. 25, 1866), we find that in the simple bent or folded eyeless shield or carapace they are closely related, but in the structure of the body they differ materially. Hymenocaris has, in one instance, 9 strong segments shown in its more elongate body, the terminal one ending in three pairs of spines; usually 6 or 7 segments are seen; 8 or 9 are less frequent (Brit. Assoc. Rep. 1883, p. 219). Protocaris has 30 narrow segments, a large terminal segment or telson, with two rather strong caudal or terminal spines.

PROTOCARIS MARSHII Walcott.

Plate xv, fig. 1.

Protocaris Marshi Walcott, 1884. Bull. U. S. Geol. Survey, No. 10, p. 50. (Dated 1884, but not generally distributed until 1885.)

The specimen on which the genus and species are founded is compressed between the laminæ of the slate so that the entire outline of the carapace is shown and the body is widened out. As flattened the carapace is rounded quadrangular in outline, with a more or less distinctly defined marginal rim all around. The general surface appears to have been smooth. No evidence of eyes.

The body projecting beyond the carapace is about two-thirds as long as the carapace, narrowed posteriorly and made up of numerous narrow segments, each about one-third of a millimeter in breadth; the last segment or telson, which is 2.5^{mm} long, supports two caudal spines 7 or 8^{mm} in length; 30 segments appear between the posterior edge of the carapace and the telson; the segments appear to have been smooth and without a spinose or crenulated posterior margin; the telson and caudal spines also appear to have been smooth and without ornamentation.

Dimensions.—Total length, 42^{mm}; length of carapace, 21^{mm}; width, 26^{mm}; length of body, 15^{mm}, exclusive of caudal spines; width of body where it passes beneath the carapace, 10^{mm}; at telson, 4^{mm}.

The specific name is given in honor of Prof. O. C. Marsh.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's farm, town of Georgia, Vermont.

This is probably the oldest Phyllopod crustacean known at the present time. We know nothing of the animal that inhabited the shell (the shell itself is flattened by compression), but by flattening out the carapace and segmented body of *Apus glacialis*, or any allied form, we see at once the striking resemblance between the recent Apus and ancient Protocaris, the most marked difference being the absence of eyes in the Cambrian Protocaris.

Mr. J. L. Kingsley requested me to study Protocaris with a view of ascertaining its relations to Apus, but the material is too imperfect to arrive at a satisfactory conclusion. The animal is Apus-like, and it also appears to be connected with the Nebalidæ through Hymenocaris, Peltocaris, Ceratiocaris, &c. In this connection I wish to quote an observation by Prof. E. Ray Lancaster. He says: "Apus cancriformis is, in many respects, one of the most important of the Crustacea. * * * It possesses peculiarities of organization which mark it out (together with its immediate congeners, the Phyllopoda) as an Archaic form, probably standing nearer to the extinct ancestors of the Crustacea than any other living members of the group." ("Observations and reflections on Appendages and on the Nervous System of Apus cancriformis," Quart. Jour. Micro. Sci., vol. xxi, n. ser., p. 343, 1881.)

PŒCILOPODA.

Genus AGNOSTUS Brongniart.

Agnostus Brongniart, 1822. Crust. Foss., p. 38, pl. iv, figs. 4*a*, *b*.

AGNOSTUS INTERSTRICTUS White.

Plate xvi, figs. 6, 6*a*.

Agnostus interstrictus White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid., Prelim. Rep. Invert. Foss., p. 8. *Idem*, 1875. Vol. iv, pt. 1, p. 38, pl. ii, figs. 5*a*, *b*.

Original description.—"Head and pygidium of almost exactly equal size and general shape and otherwise closely resembling each other.

"Head a trifle broader than long, regularly rounded in front; sides at the postero-lateral regions subparallel; postero-lateral angles truncated; the whole exterior margin, including the truncated portions just named, provided with a narrow, raised rim, the elevation of which forms a linear depression, or groove, between it and those portions of the head which it incloses; space between this marginal depression and the glabella a little wider posteriorly than it is in front, convex throughout, and its surface apparently smooth. Glabella conical, widest posteriorly, moderately convex, sides nearly straight, well defined by the dorsal furrows, abruptly rounded in front; a minute tubercle situated on the median line near the posterior end, and a shallow groove or furrow extending across near the front end, defining a frontal lobe of moderate size.

"Thorax narrower than the head and pygidium, giving the body the appearance of being constricted at the middle; axial lobe broad, consisting of two segments, both of which are tumid at the ends adjoining the dorsal furrows; lateral lobes very narrow; pleuræ almost as wide as long; each pleura tumid and rounded at its exterior end.

"Pygidium having an outline like that of the head, and is also provided with a similar elevated marginal rim and linear depression within it; axial lobe a little longer than the glabella, and consequently that lobe reaches a little nearer the posterior margin of the pygidium than the glabella does to the anterior margin of the head, moderately convex in elevation and also in each lateral outline; a minute tubercle is situated on the median line near the anterior end, corresponding in size and relative position with the one on the glabella before mentioned; space between the dorsal furrows and the margin convex, its surface apparently smooth; upon the outer edge of the border of the pygidium, at each side and a little nearer to the axial extremity than to the antero-lateral angles, there is a minute protuberance, suggestive of an incipient spine. Besides the slight differences between the head and pygidium, already referred to, the pygidium differs also in having a faint appearance of segmentation of its axis and in a slight folding backward of the marginal rim at the antero-lateral angles.

"Length of body, 8mm; width of head and also of the pygidium, 5mm; width of thorax, 4mm.

"This beautiful *Agnostus* is quite unlike any described American species, and is more nearly related to *A. integer* Beyrich, from the Primordial strata of Europe, than any other known to me. Compared with that species, it is found to reach a larger size; its glabella is narrowed in front instead of having its sides nearly parallel; the axial lobe of the pygidium is narrower behind than in front, instead of being of nearly the same width at each end, and has the sides of that lobe convex instead of nearly straight, as they are in *A. integer*."

Direct comparison with specimens of *Agnostus pisiformis* shows a striking similarity between it and *A. interstrictus;* the differences consist in the form, and this is owing largely to the compression to which *A. interstrictus* has been subjected. *Agnostus bidens* Meek (see Monographs U. S. Geol. Survey, vol. viii, p. 26) and *Agnostus tumidosus* H. & W. (Geol. Expl. Fortieth Par., vol. iv, p. 231), of the Upper Cambrian, are also closely connected with varieties of *A. pisiformis.*

Our knowledge of the American species of the genus Agnostus is now very imperfect, and much work is needed to obtain a thorough understanding of them.

A species of Agnostus occurs in the Prospect Mountain Cambrian limestone of the Eureka District, Nevada, that appears to be, in the head shields, identical with *A. interstrictus.* It also may be identified with *A. communis* H. & W. (Geol. Expl. Fortieth Par., vol. iv, p. 228, pl. 1, figs. 28, 29). Not wishing to introduce a doubtful occurrence of another species into the fauna, I identify the head shield with *A. interstrictus*, which we know to occur at about this horizon at another locality.

Formation and localities.—Middle Cambrian. Bluish-gray calcareous shale, House Range, Antelope Spring, Western Utah; Shaly limestone, 500 feet above quartzite, east slope Prospect Mountain, Eureka District, Nevada.

AGNOSTUS NOBILIS Ford.

Plate xvi, fig. 7.

Agnostus nobilis Ford, 1872. Amer. Jour. Sci., 3d ser., vol. iii, p. 421, figs. 1, 2.

Original description.—"Head and pygidium of nearly the same size and form, both exceedingly convex. The head is broadly semi-elliptical, wider than long, the length to the breadth about as 5 to 6. Convexity greatest along the median line, reaching its maximum on a straight line joining the posterior angles. From thence the slope is nearly equal to the front and sides. The sides, anterior margin, and part of the posterior margin, abruptly concave, rounded, and slightly incurved. Posterior angles rounded. The posterior outline is slightly concave for a short distance on either side of the middle, leaving a strong, tapering, median projection. The extremity of this projection is truncate and appears to form a nearly flat articulating face. The head is surrounded by a narrow convex border directed a little downward, of uniform width, or but slightly attenuated on the posterior outline. On either side of the head this border is set off with a row of prominent tubercles, from seven to eight in each row. No tubercles have been observed on the extreme front and posterior portions of the border. The surface of the head, including the border, is transversely crossed by numerous faintly impressed lines, curving backward, for the most part invisible to the naked eye.

"The pygidium is of equal length and width with the head. The convexity, however, is a trifle greater along the middle, and the anterior angles rather less rounded than the corresponding angles of the head. The greatest convexity occurs at the anterior third of the pygidium. The anterior outline is slightly concave at the middle and is then feebly rounded in passing outward and backward to the angles. The contour of the sides and posterior margin the same as that of the sides and anterior margin of the head. A narrow marginal border similar to that of the head, though not tuberculated, surrounds the pygidium, terminating on either side of the concave portion of the anterior outline. The surface is covered with delicate lines similar in character and direction to those of the head.

"The two extremities are connected by a single thick thoracic ring. This ring is partly shown in the figure. From the appearance of the figure, however, there would seem to be room for a second ring, but this appearance is due to the damaged condition of the head.

"Two specimens only of this species have been obtained, one a head with a small portion of the pygidium; the other a nearly perfect individual. The dimensions of the latter are as follows: Length of entire animal, .64 of an inch; length of head along the median line .30, width at posterior angles .36 of an inch; median length of pygidium .30, width at anterior angles .36 of an inch; width of head and pygidium at one-third the length of each from their smaller extremities, each .28 of an inch; width of thoracic ring, .10 of an inch. This is likewise the width of the concave portion of the pygidium with which it lies in contact. Greatest depth of pygidium .14 of an inch; greatest depth of head .12 of an inch.

"The proportions of the other head slightly different, the length being .34, the width .39, and the greatest depth .14 of an inch. The specimens were found lying close to each other in the same hand fragment of limestone. Occurs in even-bedded limestone east of Troy, New York, in the same layer with *Olenellus asaphoides*, *Agnostus lobatus*, *Obolella cælata*, and *O. desquamata*."

Mr. Ford states that he is not sure which is the cephalic shield; also, that the species is of the same type as *A. parilis* Hall, of the Potsdam sandstone of Wisconsin, but it differs in size characters too much to be specifically related. Mr. Ford informs me that the type specimen is lost, so we can only reproduce the rough wood cut given with the original description.

Formation and locality.—Middle Cambrian. Even-bedded limestone on the ridge east of the city of Troy, New York.

Genus MICRODISCUS Emmons.

Microdiscus Emmons, 1855. Amer. Geol., vol. i, pt. 2, p. 116.

Type, *M. quadricostatus.*

Original description.—"Minute, oval, middle lobe of the cephalic shield strongly developed; ribs of the body or abdomen, four; of the tail, four or five. The form of the cephalic shield is only obscurely indicated; the size of this trilobite is shown in the small figure. It is found in the white fragile shales of Augusta County, Virginia, associated with minute molluscas and graptolites."

I have long had a suspicion that the original specimen on which the species *M. quadricostatus* was founded was a young specimen of *Trinucleus concentricus*, or a species of that genus, although it might be the young of some species of the genus Ampyx; the former is more probable, as specimens of the latter genus are of rare occurrence in American strata and *Trinucleus concentricus* is quite abundant at the same horizon in which Dr. Emmons found the specimen described by him. It is the type of the young Trinucleus, as may be seen by comparing it with Barrande's figure of *T. ornatus*, showing four segments in the thorax. The glabella is clavate and of the type of that of Trinucleus; the pygidium is essentially that of Trinucleus, as are also the thoracic segments. When collecting from the Hudson River shales, in Central New York, I found the heads of *T. concentricus* distorted and with the punctate margin and genal spines so broken away that they appeared similar to the head of *M. quadricostatus.* We now know that the light-colored, fragile shales of Augusta County, Virginia, belong to the Hudson River group, and that they carry graptolites and minute shells such as Dr. Emmons mentions. In view of these facts and since all the species subsequently referred to the genus Microdiscus have the head and pygidium subequal in size and form and a cylindro-conical glabella, I am inclined to consider Emmons's type as belonging to the genus Trinucleus and take as the type of Microdiscus the next species referred to it, *M. punctatus.*

The above was written before I had read M. Barrande's observations on the same trilobite. He was of the opinion that Dr. Emmons was probably in error in referring the species to the lowest geologic horizon of his Taconic system and that *M. quadricostatus* recalled the young of Trinucleus: "D'après cette circonstance, que la forme de la tête est obscurément indiquée, il est impossible de juger avec sécurité la nature de ce Trilobite. Sa taille et ses apparences nous porteraient à croire que le spécimen figuré représente le jeune âge de quelque espèce dont les individus adultes n'ont pas encore été observés. En outre, la grande saillie de la glabelle, le nombre des segments libres au thorax et des segments encore soudés au pygidium, rappellent les apparences des jeunes Trinucleus. Ces observations ne doivent pas être considérées comme une détermination générique, qui serait trop hasardée, d'après des documents si incomplets." (Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 280.)

Mr. Salter, in describing *Microdiscus punctatus*, remarks that Barrande thinks that the minute form described by Emmons may be the young state of Trinucleus or some such Lower Silurian genus, but that Emmons's figure is singularly like the fossil he had under observation and that he did not feel inclined to institute a new genus for it while there was a possibility that it might be the *fry of some larger trilobite.*

The discovery of several well-characterized species and the reference of *Agnostus lobatus* to the same group have fairly established a generic form, and the old name proposed by Emmons, although no longer applicable to the type species of the genus, is retained and the genus defined as follows:

Trilobites of a small size; elongate-oval in outline; head and pygidium subequal, without eyes or facial sutures; glabella elongate, conical or cylindro-conical, with or without glabellar furrows and occipital furrow; pygidium with or without grooved pleural lobes; thorax with three or four segments; pleural lobe of segments grooved, much as in the Paradoxidæ.

Types, *M. punctatus*, *M. speciosus.*

In classification, Microdiscus occupies a position intermediate between Agnostus and Conophrys (Callaway Quart. Jour. Geol. Soc., vol. xxxiii, p. 667) or Shumardia (Billings, Pal. Foss., vol. i, p. 92), if the latter is found to have a thorax similar to that of Conophrys.

As in the genus Agnostus, there is considerable range of variation between the species referred to the genus.

The glabella of both *M. punctatus* and *M. pulchellus* carries a strong nuchal spine; otherwise the head is of the same type as that of *M. sculptus*, *M. speciosus*, *M. Dawsoni*, *M. lobatus*, *M. Parkeri*, and *M. Meeki*. The pygidia of *M. punctatus*, *M. pulchellus*, and *M. speciosus* are similar in form, while those of *M. sculptus*, *M. lobatus*, *M. Parkeri*, and *M. Dawsoni* resemble each other in having the pleural lobes strongly ribbed, a more transverse outline, and a more strongly defined marginal border.

Pemphigaspis bullata Hall (Sixteenth Rep. N. Y. State Cab. Nat. Hist., p. 221) appears to be closely related to this group, but until more is known of it I do not think we can indicate its relations to the Agnostidæ, the family under which Microdiscus is placed. Conophrys and Shumardia are also placed under the same family as trilobites with few segments and without eyes or facial sutures.

The genus Microdiscus, so far as we now know it, appears to be confined to the Cambrian system; *M. punctatus*, *M. sculptus*, and *M. pulchellus* appearing in the Lower Cambrian; *M. speciosus*, *M. Meeki*, *M. Parkeri*, and *M. lobatus*, in the Middle Cambrian; and, if *Pemphigaspis bullata* proves to belong to the same group, we have one species from the Upper Cambrian, and all the species now referred to Microdiscus would then be referred to Pemphigaspis, as Emmons's original name of *Microdiscus* could not be retained, as it appears to have been founded on a specimen of the genus Trinucleus.

In my review of the fauna of the St. John group of the Hartt collection I referred the St. John species to *M. Dawsoni* and *M. punctatus*. A reconsideration of the last species causes me to refer it to the species *pulchellus*, a name proposed by Mr. Hartt in cataloguing the species of the St. John Formation (Bull. U. S. Geol. Survey, No. 10, p. 24).

MICRODISCUS SPECIOSUS Ford.

Plate xvi, figs. 3, 3*a–c*.

Microdiscus speciosus Ford, 1873. Amer. Jour. Sci., 3d ser., vol. vi, p. 137, figs. 2*a*, *b*.
Idem, 1877. Same journal, vol. xiii, p. 141.

Original description.—"Head destitute of eyes and sutures, semi-elliptical, with a conspicuous border all around, thickened at the edge, which in the majority of cases carries from five to six minute tubercles on each side; border expanded in front. Glabella long, conical, prominent, smooth, without neck furrow, extending in an obscurely triangular projection slightly beyond the posterior outline, separated from the cheeks by rather wide and deep dorsal furrows, sometimes, though only in very rare instances, obscurely lobed by from three to four faint furrows on each side. Cheeks convex, prominent, well defined by the dorsal and marginal furrows. Posterior angles narrowly rounded.

"Thorax with four equal segments. Pleuræ pointed, straight except at their extremities, which are bent down and slightly recurved, deeply grooved for nearly their whole length. The rings of the axis have a slight groove across them in the posterior half of each. The fourth or hindmost ring appears to be anchylosed to the pygidium; at least, it invariably accompanies it when the latter is found isolated.

"Pygidium as long as the head and of nearly the same shape, but slightly narrower, taking the extreme measurements and more rapidly tapering, gracefully curved in outline. Marginal rim distinct all around, widest anteriorly, distinctly raised or thickened at the edge. Axis conical, sometimes acutely so, long and slender, extending very nearly to the margin, divided by faint cross furrows, directed slightly backward into eleven rings or segments. Side-lobes highly convex and without furrows. The axis and side lobes appear to overhang the marginal rim at the posterior extremity, giving the border the appearance of being only about half as wide behind as it is in front.

"The entire surface is finely punctate. In one specimen of the pygidium, out of a large number of perfect specimens examined, there appears to be a twelfth ring in the axis.

"Length of a specimen of the usual size with all the parts in place, but too imperfectly preserved to be figured, half an inch. Length of thorax, 0.13 of an inch. I have seen but a single specimen showing conclusively the true number of thoracic segments. This species had the habit of rolling itself up into a ball, and is quite often found in this state. In the specimen just noticed, the pygidium is bent slightly under the body. Nearly all of the specimens that I have seen that were in a perfect condition before extraction, exhibit this tendency to coil themselves up, which appears to account for the thorax breaking away in most cases.

"This pretty little trilobite occurs in both even-bedded and conglomerate limestones of the Lower Potsdam at Troy; also, at Bic Harbor, Canada, where it has been collected by Mr. T. C. Weston, of the Geological Survey of Canada. The Troy specimens were collected by the writer. It is a rather common fossil at Troy, the head and pygidium usually occurring detached from the thorax. The head sometimes attains a length of 0.38 of an inch, but this is quite unusual.

"This species closely resembles *Microdiscus punctatus* (Salter), from the Menevian group of Wales (Quart. Jour. Geol. Soc., Aug., 1864, p. 237); but it differs from that species in not possessing a neck spine, in the greater number of its caudal rings, and in having the marginal rim of the head tuberculated. The head, compared with that of *Microdiscus Dawsoni*, from the St. John group of New Brunswick (Acadian Geology, Dawson, 1868, p. 654), is proportionally longer, and is wanting in the grooves of the border of that species."

Mr. Ford subsequently discovered more perfect specimens than those from which the above description was drawn, that proved that the thorax was composed of three segments, also that the posterior segment was not anchylosed to the pygidium.

The pygidium of *Microdiscus pulchellus* Hartt is of the same type as that of *M. speciosus*, and it has eleven rings on the axial lobe. The head, however, varies materially in the possession of a strong nuchal spine, crenulated border, and in the proportions of the glabella and cheeks.

M. speciosus is not a rare form at Troy, although not occurring in as great abundance as *M. lobatus*.

Formation and localities.—Middle Cambrian. Conglomerate and even-bedded limestones, on the ridge east of Troy, New York; also, at Bic Harbor, Canada.

MICRODISCUS MEEKI Ford.

Plate xvi, fig. 4.

Microdiscus Meeki Ford, 1876. Amer. Jour. Sci., 3d ser., vol. xi, p. 371.

Original description.—"Head broadly rounded in front, nearly semi-oval in outline, greatest width at about the mid-length, slightly narrowed in passing backward from this point to the angles. Glabella conical, about two-thirds the length of the head, with two straight, moderately deep furrows extending all across, dividing the glabella in advance of the neck furrow into three parts of nearly equal length. Neck furrow extending all across and deeper than the other glabellar furrows. The form of the neck segment cannot be clearly made out, owing to the damaged condition of the specimen at this point. Dorsal furrows narrow, not deep, dying out toward the front of the glabella. Cheeks prominent, much swollen in the posterior third, without eyes or sutures. Marginal rim well defined all around, widest in front, with a conspicuously raised edge, inside of which there is a nearly flat or feebly concave space, and so bent upward in front as to give to the head, on a side view, a kind of slipper-like appearance. On either side of the head, just inside of the raised marginal edge, there are three small tubercles situated within the limits formed by a line drawn across the head through the middle of the cheeks and another drawn parallel with it just in advance of the front of the glabella.

"Greatest width of the head, one and one-half lines; length along the median line, including the neck segment, the same. Differs from *Microdiscus* (*Agnostus*) *lobatus* Hall (Pal. N. Y., vol. i, p. 258, pl. lxvii, figs. 5*a–f*), from the same locality, in its shorter and transversely furrowed glabella, its tuberculated margin, and in its general proportions."

The figure illustrating this species was drawn by Mr. Ford from the type specimen, which is the only one yet known of the species.

Formation and locality.—Middle Cambrian. Conglomerate limestone, on the ridge east of Troy, New York.

MICRODISCUS LOBATUS Hall (sp.).

Plate xvi, figs. 1, 1*a*, *b*.

Agnostus lobatus Hall, 1847. Pal. N. Y., vol. i, p. 258, pl. lxvii, figs. 5 *a*, *f*.
Microdiscus lobatus Ford, 1873. Amer. Jour. Sci., 3d ser., vol. vi, p. 135, foot-note.

Original description.—"Minute, trilobate, with a narrow border around the base and sides; middle lobe often with a small tubercle near its larger extremity.

"This species bears considerable analogy to the Swedish specimens from a similar geological position, but they are not identical. Our species is always smaller, and I have never seen the small node or tubercle at the base of the central lobe; but it presents a similar character on the other extremity. All our specimens have the appearance of the caudal shield of a small trilobite, and two or three individuals are apparently articulated."

The head is convex, bordered all around by a strong marginal rim, and without eyes or facial sutures. Glabella prominent, cylindro-conical; in the greater number of examples there are no traces of glabellar furrows, but in others the furrows are indicated by slight indentations close down by the lateral margins; in some specimens there is one furrow that cuts entirely across above the well-defined occipital furrow, and in some a second furrow, so that the glabella is divided into three nearly equal lobes by the two well-marked transverse furrows; the form of the glabella also varies from cylindro-conical to semi-cylindrical, and the outline of the head varies in its relative length and breadth. The cheeks are strongly convex and arch over to the rounded groove within the marginal rim. Occipital segment strong and rising at the centers almost to a point or node.

Thorax unknown.

Pygidium strongly convex, bordered by a rounded rim; axial lobe prominent, divided into three equal segments and one more elongate terminal portion by three well-defined transverse furrows; lateral lobes marked by three principal furrows and three slight furrows corresponding to the pleural grooves of the thoracic segments.

A peculiarity of the head, in some of the specimens, is interesting, as it points to a feature more fully developed in the genus Shumardia (Billings, 1862, Pal. Foss., vol. i, p. 92) and the closely allied genus Conophrys (Callaway, 1877, Quart. Jour. Geol. Soc., vol. xxxiii, p. 667): it is the presence of two minute depressions running outward from the dorsal suture opposite the anterior end of the glabella, the space between them being connected with the glabella by a low ridge crossing the dorsal suture. This character is spoken of under the genus Microdiscus.

The small heads of *Microdiscus speciosus* appear much like those of *M. lobatus*, but they differ in form and the pygidia are entirely different. The most nearly related species to *M. lobatus* known to me is *M. sculptus* Hicks (Quart. Jour. Geol. Soc., vol. xxvii, p. 400, pl. xvi, figs. 9, 9*a*, 10, 10*a*). The figures of *M. sculptus* are not very clear, and no description is given, but, with the means of comparison we have, the two appear to have many points in common.

Formation and locality.—Middle Cambrian. Conglomerate limestone, on the ridge east of the city of Troy, New York.

MICRODISCUS PARKERI n. sp.

Plate xvi, figs. 2, 2*a*.

Head and pygidium subequal in size and form, strongly convex, and with a narrow, prominent, median lobe.

The marginal border of the head is narrow; glabella narrow, elongate-conical, and reaching to the anterior border, without transverse furrows except an indication of a shallow occipital groove; cheeks convex but not tumid; posterior margin with a narrow groove inside the margin.

Without eyes or facial sutures.

Thorax unknown.

Pygidium with a narrow marginal rim; medium lobe narrow, elongate-conical, and extending to the posterior groove just within the margin;

divided by transverse furrows into eight or nine rings; lateral lobes marked by *six or seven* ribs that extend out to the margin. Surface characters unknown.

This species is very closely allied to *M. sculptus* Hicks (Quart. Jour. Geol. Soc., vol. xxvii, p. 400, pl. xvi, figs. 9 and 10), from the Longmynd Group. It differs somewhat in the proportions of the glabella and pygidium, as far as may be judged from the figures given of *M. sculptus*.

The specific name is given from the name of the quarry where the greater portion of the Georgia fauna of Vermont has been found. The present Noah Parker's father discovered the trilobites that were sent to the Rev. Z. Thompson, who forwarded them to Prof. Hall. They were then described, and one, *Olenellus Thompsoni*, was named after Mr. Thompson. I wish to connect the name of the original discoverer of the locality with the fauna and the locality. The quarry is now known as Parker's trilobite quarry and is located about one mile north of Georgia Plains post office.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's quarry, township of Georgia, Franklin County, Vermont.

Genus MESONACIS *Walcott.*

(μέσος, middle, and ἀκίς, point, spear.)

Mesonacis Walcott, 1885. Amer. Jour. Sci., 3d ser., vol. xxix, p. 328, figs. 1, 2.

Type of the genus *Olenellus Vermontana* Hall, the generic characters are given under the description of the species. The genus is referred to the family Paradoxidæ and is regarded as occupying, in classification, a position between the genera Paradoxides and Olenellus.

MESONACIS VERMONTANA Hall (sp.).

Plate xxiv, figs. 1, 1*a*, *b*.

Olenus Vermontana Hall, 1859. Twelfth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 60, fig. 2; Pal. N. Y., vol. iii, p. 527.

Barrandia Vermontana Hall, 1860. Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 117. *Idem*, 1861. Geology of Vermont, vol. 1, p. 370, vol. ii, pl. xiii, fig. 2.

Paradoxides Vermonti Emmons, 1860. Manual of Geology, p. 280, note A.

Paradoxides Vermontana Barrande, 1861. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 277, pl. v, fig. 8.

Paradoxides Vermontana Billings, 1861. Geology of Vermont, vol. ii, p. 950, 1863. Geology of Canada, p. 953.

Olenellus Vermontana Hall, 1862. Fifteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 114. (Generic name *Olenellus* proposed.)

Olenellus Vermontana Billings, 1865. Pal. Foss., vol. i, p. 11.

Olenellus Vermontana Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. i, p. 152. (Referred to *Olenellus Thompsoni.*)

Mesonacis Vermontana Walcott, 1885. Amer. Jour. Sci., 3d ser., vol. xxix, p. 328, figs. 1, 2.

The original description of the species is as follows:

"General form elongate; the posterior extremity obtuse. Head semioval, twice as wide as long, the posterior angles produced in short acute spines. Eyes narrow, elongate; the space from the center of the head to the outer margin of the eye much greater than the cheek, and the distance from the anterior angle of the eye to the frontal margin less than the length of the eye. Glabella lobed; hypostoma broad oval.

"Thorax imperfect, preserving six articulations and part of the seventh; the middle lobe wider than the lateral ones. The third articulation is much broader towards and at its lateral margin and is prolonged obliquely downwards in a sharp spine, which reaches below the seventh articulation; the lateral extremities of the other articulations produced in short, acute spines.

"Another fragment, which is apparently of the same species, preserves eleven articulations of the thorax and the pygidium. The upper articulations are imperfect at their extremities; the last one is bent abruptly downwards, and terminates in a long spine on each side reaching below the pygidium. Pygidium semioval; the axis marked by four annulations, the two upper of which are faintly indicated in the lateral lobes.

"This species differs from the preceding in its proportionally narrower form, the relative proportions of the parts of the head, and the short, acute posterior spines. The comparative width of the middle and lateral lobes of the thorax is a very distinguishing feature.

"*Geological position.*— In the shales of the upper part of the Hudson River group."

The fragment of the thorax and pygidium described above proved, on subsequent examination, to be a portion of *Bathynotus holopyga* (Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 389), which left the posterior portions of *O. Vermontana* undescribed.

No further information of the species has been published to date. Mr. Whitfield (Bull. Amer. Mus. Nat. Hist., vol. i, p. 152) says: "On a critical examination of these forms and comparison with the different sizes of *O. Thompsoni* in the collection, I find that the distinctive features of *O. Vermontana* become less and less marked and become merged into those of *O. Thompsoni* as the specimens increase in size, and I am inclined to think the two species represent only different stages of growth or development of one form." He also figures on plate xv three specimens of *O. Thompsoni* as *O. Vermontana*.

The species is of rather rare occurrence. During the summer of 1883, the writer obtained one specimen, and two more the following year. They were associated with *Olenellus Thompsoni*. Mr. Edward Hurlburt, of Utica, New York, collected at the same locality, and fortunately found a very perfect specimen with its matrix; the latter was secured for the National Museum collections, and a cast taken from it which is the original of the figure on plate xxiv. Mr. Hurlburt kindly loaned the relief specimen for study, and from it and three other specimens the following description is drawn:

Description.—General form narrow, elongate, tapering gradually from the base of the head to the pygidium.

Head three-tenths the length of the entire animal; length and breadth as 3 to 4½. Margin bordered by a narrow, rounded rim that is continued at the genal angles as comparatively short aciculate spines; posterior side transverse to the pleural angle,[1] where it bends obliquely forward to the genal angle, a small short spine marking the pleural angle. Glabella elongate, of nearly the same width throughout, and marked by four lobes, the anterior of which is large, subcircular, and more or less convex; the three posterior transverse lobes are of nearly equal size, the first and second being confluent at their extremities and uniting with the anterior end of the palpebral lobes; occipital segment rather broad and not well defined from the glabellar lobes preceding it. Eyes elongate, narrow, and arching from opposite the anterior glabellar furrows back to a point opposite the second posterior lobe of the glabella and at a little distance from the dorsal furrow. Fixed and free cheeks not definitely separated anteriorly; back of the eye the facial suture extends obliquely outward, cutting the posterior rim of the head at the pleural angle. Free cheeks large, roughly subtriangular.

Thorax elongate, tapering gradually to the pygidium; segments, 26; the two anterior segments arch slightly forward and terminate abruptly, the postero-lateral angle of the pleura being produced into a short backward-pointing spine; the third segment has its pleural lobes greatly developed in width, and terminating in a strong spine on the same plane as those on the two anterior segments; the 14 segments back of the large third segment are uniform in character, decreasing in breadth, but having the geniculated portion of the pleural lobe increasing in length and size; the fifteenth segment is deeper than the fourteenth on the axial lobe, but the pleural lobes are much shorter, and a long acicular dorsal spine arises at the center of the axial lobe and extends back over the succeeding 11 segments to the pygidium or beyond; the 11 posterior segments are smaller and appear to have been of a more delicate texture than the anterior 15 segments. The pleural groove of the lateral lobes is broad, flat, and continued outward beyond the genal angles to the union of the two margins of the segment to form the terminal spine or point.

Pygidium small, ovate, terminating in three points posteriorly; the axial lobe occupies all the central portion, leaving a narrow pleural lobe on each side; posterior margin concave between the outer terminal points, and with a slight point at the center.

Surface of the entire body, except the free cheeks, very finely granulose under a strong magnifier; from the base of the eyes, irregular, venulose lines radiate towards the outer margin.

Observations.—The genus appears to be one intermediate between the genera Paradoxides and Olenellus, or a form in which the character-

[1] The pleural angle is the angle of the posterior margin of the head, opposite the geniculation of the pleural lobe of the thorax.

istics of Paradoxides are changing into those of Olenellus, the head and the first 14 segments being in all particulars the type of Olenellus, and the pygidium and 10 posterior segments more the type of Paradoxides; the fifteenth segment represents the telson of *Olenellus Thompsoni*.

Under remarks on the genus Olenellus, the relationships to that genus are mentioned, and we will next consider the body of Mesonacis back of the fourteenth segment.

The fifteenth segment fits snugly up against the fourteenth; the axial lobe is strong and supports the base of a long, slender spine that, as now preserved, extends back to the pygidium; the base of the spine originates on the dorsal surface of the segment and also extends back so as to include the posterior margin, and causes the latter to curve back towards the center; the lateral pleuræ of the segment are short, and in their structure are diminutive representatives of the large pleuræ of the segments anterior to the fifteenth.

The succeeding eleven posterior segments appear as though formed of a more delicate test than the anterior portions of the body, as they are much more flattened and compressed than the latter and the pleural grooves are almost obsolete. The pygidium is also small and delicate.

The body back of the spine-bearing segment appears as though belonging to a different animal, and looks more like that of a Remopleurides than either Olenellus or Paradoxides, but, on a close examination, the pygidium is found to be much like that of *Paradoxides rugulosus*, and the free pleuræ bend back as in that species. (Compare fig. 1*b* of plate xxiv with fig. 2 of same plate.)

Comparison with other genera and species.—The form of the head is similar to that of *Olenellus Thompsoni*, except that in the less compressed examples it is not proportionally as broad; this may be also said of the entire body. The genal spines are more slender and the frontal glabellar lobe is closer to the anterior margin.

Among the described species of the genus Olenellus some specimens of the head of *O. Gilberti* approach very closely to that of *Mesonacis Vermontana*, and I was surprised when I found that the former did not prove to be generically or specifically related to the latter.

We do not find among the American species of Paradoxides forms to compare with either Olenellus or Mesonacis, except in the outline of the posterior margin, as mentioned under the genus Olenellus. Europe gives one from Sweden, *P. Kjerulfi*,[1] the head of which shows other features common to Olenellus and Mesonacis, as mentioned under the description of the former genus.

In the contour of the adult form of the head, *P. spinosus*, *P. Sacheri*,[2]

[1] Öfversigt k. Svensk. Vet.-Akad. Förhand. N:o 6, p. 790, Tafl. xvi, figs. 1, 2. Stockholm, 1871.

[2] Syst. Sil. Bohême, vol. i, 1852.

&c., may be compared with the species under consideration. The glabella and the eye lobes vary from all except *P. Kjerulfi*.

The thorax has already been spoken of in the remarks following the description.

The denticulated form of pygidium in the genus Paradoxides with two terminal points is shown in the pygidia figured by Mr. Matthew[1] from the St. John group; and on the pygidia of *P. rugulosus* Corda, *P. Lyelli* Barrande, *P. expectans* Barrande, and *P. Oelandicus* Linnarson, four terminal points occur, as far as can be determined. The one specimen showing the pygidium of *M. Vermontana* has three terminal points, one central and one on each side.

Under the general remarks on the genera Olenellus, Mesonacis, and Paradoxides, the generic relations of *Mesonacis Vermontana* are still further discussed.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's quarry, township of Georgia, Franklin County, Vermont. Specimens corresponding to the head of this species occur at Bonne Bay, Newfoundland, and L'Anse au Loup, on the north side of the straits of Belle Isle.

Genus *OLENELLUS* Hall.

Elliptocephala Emmons, 1846. Agriculture of New York, pt. 5, p. 65, figs. 1–3.
Elliptocephalus Emmons, 1855. Amer. Geol., pt. ii, p. 114.
Elliptocephalus Marcou, 1860. Proc. Boston Soc. Nat. Hist., p. 371.
Olenus Hall, 1859. Twelfth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 59.
Olenus Marcou, 1880. Bull. Soc. Géol. de France, 3e sér., t. ix, p. 25.
Barrandia Hall, 1860. Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 115. *Idem*, 1861. Geology of Vermont, vol. i, p. 369.
Paradoxides Emmons, 1860. Manual Geol., p. 280.
Paradoxides Barrande, 1861. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 277.
Paradoxides Marcou, 1862. Proc. Boston Soc. Nat. Hist., p. 245.
Paradoxides Billings, 1861. Geol. Vermont, vol. ii, p. 950. *Idem*, 1863. Geol. Canada, p. 953.
Olenellus Hall, 1862. Fifteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 114.
Olenellus Marcou, 1862. Pamphlet, p. 5. Cambridge, Mass.
Olenellus Billings, 1865. Pal. Foss., vol. i, pp. 11, 365.
Olenellus Ford, 1877. Amer. Jour. Sci., vol. xiii, p. 265.
Olenellus Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. i, p. 151.
Olenellus Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 28.

Dr. Emmons originally placed a species of this genus under the generic name of Elliptocephala (1846), considering it a new generic form; subsequently (1855, Amer. Geol., p. 114) he called attention to the similarity of the name to Ellipsocephalus (Zenker, 1833), but concluded "to retain it for the present." More recently the name Elliptocephala has been recognized (*Olenellus* (*Elliptocephalus*) *asaphoides*, Ford, Amer. Jour. Sci., 3d ser., vol. xiii, p. 265, 1877), but I think without good rea-

[1] Trans. Roy. Soc. Canada, vol. 1, pl. x.

son, as it differs only by an error of spelling from Zenker's genus Ellipsocephalus, the elliptical form of the head being the basis of each name.

The following is the original description of the genus Barrandia Hall, afterwards changed to Olenellus Hall:

"General form broadly ovate or elongate-ovate, distinctly trilobate. Cephalic shield broad, somewhat semicircular; the width more or less than twice the length, with the posterior angles projecting in long spiniform points; the posterior margin is nearly straight or slightly concave, with a slight sinuosity at the outer angle just within the cephalic limb; the anterior and lateral margins have a thickened or elevated border, within which is a well marked groove or depression of the crust. The glabella is well pronounced, of nearly equal width throughout, or slightly narrowing and rounded in front; marked by three pairs of furrows (perhaps from two to four), the posterior one of which is nearly or quite continuous across from the posterior angles of the eyes. The facial suture has not been fully determined, but appears to extend in a curving line from the front margin to the anterior angle of the eye, and from the posterior angle of the eye it turns abruptly outwards towards the postero lateral angle of the cephalic shield.

"Eyes large and well developed, elongate semilunate, extending from near the base of the shield more than half way to the anterior margin. Hypostoma broadly ovate, little longer than wide.

"Thorax composed of 13 or 14 articulations, the axis being moderately convex and usually much narrower than the lateral lobes (and sometimes apparently marked by a row of nodes or short spines along the summit). Lateral lobes nearly flat; the ribs, to about the eighth or ninth, extending almost rectangularly, or slightly inclined from the axis for one-third to one-half their length, where they are bent abruptly backwards. The third segment is stronger and much more prolonged than the others. The last segments of the lateral lobes are produced directly backwards, or sometimes a little convergent below. The segments of the lateral lobes are marked by a broad longitudinal furrow nearly parallel to the anterior margin; leaving an abruptly elevated ridge or border upon that side as far as the geniculation of the segment, where the groove runs along the center, dying out on the recurved extremities.

"Pygidium distinct, narrow, elongated, the axis narrow and acutely pointed; without rings? Lateral lobes narrow or obsolete, and free from transverse ridges or furrows."

The direction of the facial suture is left in doubt. For the type species *O. Thompsoni*, Prof. Whitfield has shown it as though passing from the posterior end of the eye obliquely and almost directly back to the posterior margin (Bull. Amer. Mus. Nat. His., vol. i, pl. xv, fig. 1). From the examination of a large number of well preserved specimens, I am led to think that the sutures represented are accidental breaks and not the true sutures, as we invariably find the line of the suture running obliquely outward and terminating at or very near the pleural angle. It occurs in this way in all other species of the genus in which we have observed the suture.

The sutures are shown for *O. Howelli* and *O. Gilberti* in the same manner (Expl. and Surv. West 100th Merid., vol. iv, pt. 1, pl. ii, figs. 3, 4), but with the type specimens before me I fail to find a trace of the suture indicated on the specimens of *O. Howelli*, and the one specimen of *O. Gilberti* showing the sutures has them running out to the pleural angle. Neither Mr. Meek nor Dr. White speaks of the facial sutures in his descriptions, so we conclude that the artist in charge of the drawings traced them in to meet his conception of their position.

When studying the variations in the head of *O. Gilberti* (= *O. Howelli*, Monographs U. S. Geol. Survey, vol. viii, p. 32), the writer determined the direction of the facial sutures, and found that they varied in direction with the configuration of the head, but that they always terminated at the pleural angle.

Mr. Ford, in speaking of the suture of *O. asaphoides*, says: "The shield appears to have fractured as easily in one direction as another. This would seem to indicate that the cheeks were very firmly united at the sutures in front" (Amer. Jour. Sci., 3d ser., vol. xiii, p. 271, 1877). He regarded this as the result of the metamorphoses accompanying the development of the young, when constant changes were occurring along the line of the sutures back of the eyes. After once obtaining an adult size, the test on the line of the sutures appears to have become strongly united back of the eyes, as in nearly every case the line of fracture is back from the eye to the margin, as the point of least resistance; and this is probably why the suture of *O. Thompsoni* and *O. Gilberti* have been represented at that point. In uninjured casts of the interior of the test of the head, the direction of the suture is indicated by a slightly raised line from the eye back to the pleural angle.

Pygidium.—To the original description add the word *very* before elongate.

RELATIONS OF THE GENUS TO OTHER GENERA.

Professor Hall notes the differences as compared with Olenus and Paradoxides (Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 114) as follows:

"When we compare with Paradoxides, we find the cephalic shield proportionally broader and shorter, while there is no expansion of the glabella towards the front, nor do the transverse furrows extend entirely across this part, except at its base. This feature and the facial suture, though indistinct, correspond more nearly with Olenus.

"The smaller number of thoracic segments is a distinguishing feature, and the direction of the segment-furrow differs essentially. In one feature, that of the greater development of the *third* segment, it corresponds with Paradoxides, where the *second* segment has a greater development than the others. In the extreme development of the posterior segments, in one species, there is likewise a similarity with Paradoxides In the slight development of the pygidium, our fossil corresponds in some degree with Paradoxides."

To these differences may be added that the pleural groove on the segment of Olenellus is shallower, broader, and less oblique than that of Paradoxides.

The late Mr. G. Linnarsson considered *Olenellus Thompsoni* as having no affinity to Olenus, but as a true Paradoxides or Anopolenus (Brach. Paradoxides Beds of Sweden, p. 28. Bihang till k. Svensk. Vet.-Akad. Handl. Bd. 3, N:o 12, 1876).

With the first I am in accord, but, on comparing with *Anopolenus Salteri*, as illustrated by Mr. Hicks (Quart. Jour. Geol. Soc., vol. xxi, p. 481, fig. 1, 1865), I fail to recognize the characters uniting the two forms. The remarkable development of the posterior portions of Anopolenus and the peculiar glabella and eyes serve to distinguish it as a distinct genus from Paradoxides and Olenellus; and with Paradoxides there are the differences given by Professor Hall and the writer (ante); but, as stated by Mr. Ford, the adult form of *O. asaphoides* as known to him differs only in one feature from the structural peculiarities grouped under the genus Paradoxides, and that is the segment furrow or pleural groove. To this I think we may now add "and in the elongate, simple telson or pygidium."

One marked peculiarity is that the extended pleura of Olenellus occurs on the third, while that of Paradoxides is on the second, segment of the thorax.

RELATIONS OF THE GENERA PARADOXIDES, MESONACIS, AND OLENELLUS.

As mentioned under the description of the genus Mesonacis, that genus is regarded as intermediate between Paradoxides and Olenellus, or a form preserving typical features of each genus.

Mesonacis is distinguished from Paradoxides by the character of the pleural groove of the segment, the presence of a dorsal spine on a modified form of segment on the fifteenth segment of the thorax, and the drawing in of the eye, especially of the posterior end towards the glabella. The points of resemblance are the configuration of the head, the type of the segments (except in the pleural groove), and the form of the pygidium.

The features of the head and thorax of Mesonacis, back to the fifteenth segment, are in all details essentially those of Olenellus, but the pygidium belongs to a different form and the eleven posterior segments appear to go with the pygidium rather than with the anterior portion of the thorax.

The heads of young specimens of *Olenellus Gilberti* and those adults preserving embryonic characters, show, in the position of the eye and the run of the facial suture to the posterior margin, features common to the genus Paradoxides. The eyes of *P. rugulosus* Corda and the group of Paradoxides from the St. John Group of New Brunswick approach the glabella at their anterior end, as also *P. Kjerulfi* Linnarsson, but the posterior end is distant from the glabella, as seen in the typical forms of the genus. In the normal adult of all species of Olenellus and Mesonacis known to me the eye is drawn in close towards the glabella at both ends and the suture curves out to cut the posterior margin at the pleural angle, as in Paradoxides, whether that angle be preserved or absorbed in the straightening of the margin.

Although Mesonacis is found at the same horizon as Olenellus, I regard it as showing the transition from Paradoxides to Olenellus. A Paradoxides-like form first takes the characters of Olenellus in a degree by having a spine originate on the fifteenth segment; then the body was shortened by the absorption of the pygidium and eleven posterior segments, until the elongate telson of *O. Thompsoni* is the only representative of the parts lost in the transition.

Prof. Whitfield in mentioning the telson says: "There is not the slightest evidence of any lateral lobe or expansion, or anything analogous to this part as seen on other genera, and the median ridge shown upon the specimen figured, as above referred to, does not always exist. On one specimen the fourteenth axial ring looks almost as if it might have formed an anterior lobe or ring of the telson; but in others it is seen to be distinctly separate and articulated, as are the forward axial rings to each other. This feature of the pygidium is so distinctive among all other trilobites that it alone would serve as a generic distinction, and if the condensation of parts indicates development of organization this form would appear to be below even the Paradoxides, and should precede it in age."

From our present knowledge of these forms we reverse the application made above and regard the telson as representing the condensed parts, and the form as higher in organization and succeeding Paradoxides in time.

Mr. Ford considers the relationship between Olenellus and Paradoxides one of genetic character (Amer. Jour. Sci., 3d ser., vol. xxii, p. 257, 1881), and that Olenellus is a later and higher form than Paradoxides.

We assent to this, and add that Olenellus is the representative of the group of Paradoxides of the Lower Cambrian in the Middle Cambrian, and expresses, in one of its species at least, the decadence of that branch of the type. The example is *O. Gilberti*, where, in the retention and great development of the embryonic stages of growth by adult individuals, we have an example of the loss of power in the larger number of the individuals of a species to develop to the adult form. In other words, it is an instance of retrogression towards the earlier forms of the family to which it belongs.

Olenellus Thompsoni Hall.

Plate xvii, figs. 1, 2, 4, 9; pls. xxii, xxiii, fig. 1.

Olenus Thompsoni Hall, 1859. Twelfth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 59, fig. 1 on p. 60; Pal. N. Y., vol. iii, p. 525.

Barrandia Thompsoni Hall, 1860. Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 116.

Paradoxides Thompsoni Emmons, 1860. Manual of Geology, p. 280, note A.

Paradoxides Thompsoni Barrande, 1861. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 276, pl. v, fig. 6.

Paradoxides Thompsoni Billings, 1861. Geology of Vermont, vol. ii, p. 950. *Idem*, 1863. Geol. Canada, p. 953.

Paradoxides macrocephalus Emmons, 1860. Manual of Geology, p. 88, fig. 70. On the preceding page, fig. 70 is referred to as *Paradoxides asaphoides;* but from the figure there is little doubt that it was taken from a specimen of *O. Thompsoni.*

Olenellus Thompsoni Hall, 1862. Fifteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 114. Generic name Olenellus proposed.

Olenellus Thompsoni Billings, 1865. Pal. Foss., vol. i, p. 11.

Olenellus Thompsoni Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. i, p. 151, pl. xv, figs. 1–4.

The original description of the species is as follows:

"General form ovate, the length and breadth being nearly as six to five. Head broad lunate, with the postero-lateral angles much extended; the width from the center to the outer margin of the eye almost equal to the width of the cheek. Eyes (which are much crushed in the specimen) elongate semi-oval, equal in length to the space between the anterior angles and the frontal margin; glabella distinctly lobed, narrower in front.

"Thorax with the lateral lobes about once and a half as wide as the middle lobe, consisting of fourteen articulations, the third one of which is much longer than the others, and curving downwards with an extension reaching as far as the line of articulation of the seventh rib. The posterior articulations are bent abruptly backwards, so that the free extremities are parallel with the axis. Pygidium small, pointed, without visible rings and having a narrow ridge running down the centre."

Prof. Hall revised this description in proposing the generic name Barrandia. (See description under *Olenellus*, ante, p. 161.)

In 1884 Prof. Whitfield gave a description of the direction of the facial sutures and figured examples of the species that proved the pygidium to be as given in Prof. Hall's second figure (Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 116, 1860) and also much more prolonged. Prof. Whitfield's reference to the specimen "figured in 16th Rep. State Cab." probably refers to the figure in the fifteenth report.

Our studies of this species prove that there is a narrow and broad form, as shown by plates xxii and xxiii; also, quite a range of individual variation. This is shown by Prof. Whitfield's group of figures (Bull. Amer. Mus., pl. xv), where he refers specimens varying in form to *Olenellus* (= *Mesonacis*) *Vermontana.*

Quite a marked variation occurs in two heads from near Swanton, Vermont. It is in the greater breadth of the marginal rim, as shown in fig. 1 of plate xvii. Other characters of the species are given under remarks on the genus of which *O. Thompsoni* is the type.

Formation and locality.—Middle Cambrian, Georgia formation. In the argillaceous shales of Parker's quarry, township of Georgia; east of Swanton, on the Bullard farm; west of St. Albans, in the outskirts of the city; in the massive magnesian limestones west of Parker's quarry, and also about one and one half miles east of the hotel at Highgate Springs, Vermont. Mr. Billings cites the species from Bonne Bay, Newfoundland; L'Anse au Loup, on the north shore of the Straits of Belle Isle; and the conglomerate limestones of Bic Harbor, on the St. Lawrence River, below Quebec.

OLENELLUS ASAPHOIDES Emmons, sp.

Plate xvii, figs. 4–8, 10; pl. xx, figs. 3, 3*a*, *b*; pl. xxv, fig. 8.

Elliptocephala asaphoides Emmons, 1844. Taconic System, p. 21, figs. 1, 2, 3, 1846. Agriculture of New York, vol. 1, p. 65, figs. 1, 2, 3.

Olenus asaphoides Hall, 1847. Pal. N. Y., vol. i, p. 256, pl. lxvii, figs. 2*a*–*c*. *Idem*, Fitch, 1849. Trans. N. Y. State Ag. Soc., vol. ix, p. 865.

Elliptocephalus asaphoides Emmons, 1849. Proc. Amer. Assoc. Advt. Sci., vol. i, p. 18; *idem*, 1855. Amer. Geol., vol. i, pt. 2, p. 114, figs. 1, 2, 3; pl. i, fig. 18.

Paradoxides asaphoides Emmons, 1860. Manual of Geology, p. 87, name of fig. 70. Under the figure on the following page the name is *Paradoxides macrocephalus*, and the figure is taken from an *Olenellus Thompsoni* (Barrande, 1851. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 273, pl. v, figs. 4, 5).

Olenellus asaphoides Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33. *Idem*, 1877. Same journal, vol. xiii, p. 265. *Idem*, 1878. Same journal, vol. xv, p. 129. *Idem*, 1881. Same journal, vol. xxii, p. 250.

The history of our knowledge of this trilobite may be divided into two epochs: First, that of the original discovery and description of the adult form and its connection with the Taconic controversy; secondly, that of the description of the embryonic phases of its growth; the first extending over a period from 1844 to 1850 and the second from 1871 to the present time, the period intervening between 1860 and 1871 being one in which little additional information was gained.

The material upon which this species was founded shows some of the characters of the head and thorax. The author gives figures of the head and six segments of the thorax of a large individual, a smaller crushed head, and a fragment of a thoracic segment. The same specimens were subsequently figured in the Palæontology of New York, vol. i, pl. lvii, figs. 2*a*–*c*, and accompanied by a description.

Dr. Emmons subsequently obtained a more complete specimen of the thorax, which is figured on plate i, fig. 18, of his American Geology. Fourteen segments occur in the thorax and decrease in size and length regularly from the head backward, a feature not observed in the other species of the genus and one that seems to distinguish the species from the closely related *O. Thompsoni*.

The pygidium is not shown in any of Dr. Emmons's specimens or in those obtained by Mr. Ford at Troy, New York. We have not observed it in place on the trilobite. but from finding an elongate telson like that of *O. Thompsoni* in the limestone at Troy associated with fragments of *O. asaphoides*, it is quite probable that the pygidium is of the same character. The objection to this is the broad space at the base of the fourteenth segment in the specimen figured by Dr. Emmons (Amer. Geol.), and also at the eleventh segment in Mr. Ford's figure (Amer. Jour. Sci., vol. xiii, p. 265, fig. 5, 1877). The pleuræ of the segments resemble those of *Mesonacis Vermontana* in their curvature rather than the strongly recurved pleuræ of *O. Thompsoni*, of the eleventh to the fourteenth segments. The discovery of more perfect specimens can alone determine the number of segments and the character of the pygidium.

The second epoch in the history of the species we owe to the investigations of Mr. S. W. Ford, who discovered in the limestones at Troy, New York, a number of minute specimens showing some of the metamorphoses of the species.

Two of Mr. Ford's figures I have reproduced, one showing a young stage, where the body is partially developed, and the other the mature form; illustrations are also given of two very small heads, figs. 5 and 6, plate xvii. Fig. 5 has a length of four-fifths of a millimeter, and fig. 6, of 1.75^{mm}. Mr. Ford calls the spines *x x* the interocular spines; these are absorbed during the development of the animal and also to a great extent their continuation up on the head; the surface of the latter is crossed by elevated lines corresponding in position to the glabellar furrows; they appear to indicate the original segmentation of the head, most of which is lost by absorption during the subsequent development, except on the glabella; the connection between the frontal lobe of the glabella and the ocular somite or segment is beautifully shown. As far as can be determined, the thorax is not yet developed in either specimen represented by figs. 5 and 6. Fig. 8 shows the great development of the third thoracic segment, and also the interocular spines and genal spines, which are placed so close to each other in figs. 5 and 6. A specimen figured by Mr. Ford shows them separated by a slight crevice. Fig. 8 also shows the tendency of the genal angles to extend forward, a feature so extravagantly developed in *O. Gilberti*.

Mr. Ford has discussed the metamorphoses of the young of *O. asaphoides* in a minute and able manner, and the reader is referred to his papers (Amer. Jour. Sci., 3d ser., vols. xiii, xv, and xxii) for further information.

The geographic range of *O. asaphoides* is not yet well determined, owing to the fact that when in a fragmentary condition it is impossible to detect the difference between it and *O. Thompsoni* and *O. Gilberti* when the latter is also without the thoracic segments.

Formation and localities.—Middle Cambrian. In argillaceous shales at Reynolds's Inn, northeast of Bald Mountain, Washington County, New York. Mr. Ford has also found it in the limestones on the ridge east of Troy, New York, and also one mile below Schodack Landing, New York.

OLENELLUS IDDINGSI Walcott.

Plate xix, fig. 1.

Olenellus Iddingsi Walcott, 1885. Monographs U. S. Geol. Survey, vol. viii, p. 28, pl. ix, fig. 12.

Original description.—"General outline of the head roughly subtriangular, with the length one-half the breadth of the posterior border; strongly convex; the rather narrow rounded rim bordering the anterior margin suddenly becomes thickened and rounded opposite the eyes, and is extended back in the short, strong, slightly curved, genal spines, the narrow posterior marginal border uniting with it at the genal angles. Glabella elongate, narrow, divided by four transverse furrows into five lobes; the anterior is round, tumid, and expanded laterally, while the four posterior are narrow, transverse, of equal size, and with their sides parallel; occipital ring and furrow not recognized; eyes lunate, situated opposite the central lobes of the glabella. Facial suture in front of the eye unknown; back of the eye it extends obliquely outward and backward, cutting the posterior margin about two-thirds the distance from the glabella to the postero-lateral spine.

"Thorax and pygidium unknown."

A second visit to the type locality of the species resulted in finding a number of larger heads, but no traces of the thorax or the pygidium. The most prominent peculiarity of the head is the development of the genal spines, as seen on slabs of limestone from the Groome District, Nevada, on which they appear, when broken from the head, like united valves of a species of Leperditia. From the new specimens we also discover that the occipital ring had a low, blunt point at the center of its posterior margin.

Formation and localities.—Middle Cambrian. From a fine-grained, arenaceous shale near the summit of Prospect Peak, Eureka District, Nevada, and also in limestone at the south end of the Timpahute Range, Eastern Nevada, brought in by Mr. G. K. Gilbert (Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iii, p. 169, section xviii, 2*c*).

OLENELLUS GILBERTI Meek.

Plate xviii, figs. 1, 1*a*–*c*; pl. xix, figs. 2, 2*a*–*k*; pl. xx, figs. 1, 1*a*–*l*, and 4.

Olenellus Gilberti Meek, 1874. (Manuscript.)

Olenellus Howelli Meek, 1874. (Manuscript.)

Olenellus Gilberti White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid., Prelim. Rep. Invert. Foss., p. 7.

Olenellus Howelli White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid., Prelim. Rep. Invert. Foss., p. 8.

Olenus (*Olenellus*) *Gilberti* Gilbert, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iii, Geology, p. 182.

Olenus (Olenellus) Howelli Gilbert, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iii, Geology, p. 183.
Olenellus Gilberti White, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iv, p. 44, pl. ii, figs. 3*a–e*.
Olenellus Howelli White, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iv, p. 47, pl. ii, figs. 4*a*, *b*.
Olenellus Gilberti Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 29, pl. ix, figs. 16, 16*a*; pl. xxi, fig. 13.
Olenellus Howelli Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 29, pl. ix, figs. 15, 15*a*, *b*, and pl. xxi, figs. 1–9.

In the original notice of this species by Mr. Meek, he compares it with *Mesonacis* (*O.*) *Vermontana* to show the differences between the two forms.

Mr. White gives an elaborate description of the head and fragments of the thorax; and the writer has described the Eureka (Nevada) forms, remarking that the differences between them and the type specimens are almost entirely in the frontal limb, the former having a much broader space between the front of the glabella and the marginal rim.

Mr. Meek, in describing *O. Howelli*, compared it with *O. Thompsoni* without giving a description of the parts known. Dr. White gave a detailed description of the type specimens (Geog. and Geol. Surv. West 100th Merid., vol. iv, p. 47), and the writer described them as they occur in the Eureka District.

O. Howelli was considered by Mr. Meek as distinct from *O. Gilberti*, and Dr. White and the writer followed his authority. The same specimens were studied by each observer, and it was not until after the writer had visited the type locality and secured a large collection of specimens that it was shown that the large convex head preserved in the granular limestone matrix, and named *O. Howelli*, was the same as the flattened heads in the argillaceous shales referred to *O. Gilberti*. We now have a series of heads uniting the characters shown in the typical *O. Howelli* with the typical forms of *O. Gilberti*, and, as the latter species comes first in the order of description, the specific name is retained.

The following is a description of the adult form: Outline of body ovate to elongate-ovate. The general outline of the head is semi-elliptical or semicircular, and more or less strongly convex. The margin is bordered by a narrow, rounded rim, which becomes thickened near the genal angles and is continued posteriorly in rather short, sharp spines. The glabella is elongate and more or less expanded in front and behind, contracting a little midway; four pairs of glabellar furrows penetrate from each side; they are somewhat strongly impressed on each lateral third of the width of the glabella, becoming more shallow as they pass into the less marked furrow that unites them across the center of the glabella; in the younger specimens this furrow is undistinguishable from the lateral furrows, and they all unite as one distinct furrow, crossing the glabella from side to side, and, even in the adults, this feature is strongly marked in some individuals; the anterior lobe of the glabella is more or less tumid, subhemispherical or a little transverse and wider than the greatest width of the glabella immediately behind it; the next posterior lobe is rather narrow and transverse, differing from the next two posterior lobes, which are wider and curved a little forward at the ends, by the direction of the furrows; the posterior lobe corresponding to the occipital ring or segment is broad and essentially of the same character as that preceding it; the furrow separating them is very shallow at the center and inclined obliquely backward at the sides; a small node occurs on one example at the center of the occipital ring.

Eyes elongate, narrow, and arching from opposite the anterior glabellar lobe to opposite the occipital furrow. The dorsal furrows are narrow, distinctly but not deeply impressed. Fixed cheeks a little expanded anteriorly and scarcely more than a line in width between the elongate palpebral lobes and the dorsal furrows, while posteriorly they merge into the small triangular lateral limbs; frontal limb variable; it varies in width on different specimens from scarcely a line to a broad, flattened area between the glabella and the anterior margin. Free cheeks roughly subtriangular in outline, variable in width and in the outline of the curve between the genal angle and the inner margin.

The facial suture cuts the anterior margin some distance outside the line of the outer margin of the glabella and passes obliquely inward to the anterior angle of the eye lobe; curving around the outer margin of this, it passes obliquely outward to the posterior margin, cutting it midway between the glabellar lobe and the outer margin of the genal angle.

Thorax with fourteen segments; axial lobe moderately convex and narrowing gradually to the posterior segment; lateral lobes flattened out to the geniculation of the segments; segments nearly transverse out to the geniculation of the pleural lobe, where they curve backward, terminating in long slender points; pleural groove broad, well defined, and continuing nearly to the point of the segment. The axial lobe of the third segment is developed equally with its associates, but the pleural lobes are greatly expanded and their spinose extensions are much longer and stronger than on the other segments. The form of this segment varies in different specimens.

Pygidium an elongate, slender telson, without segments or lateral lobes.

The surface of the glabella is beautifully ornamented with transverse, fine, irregularly-waving, subimbricating lines that give the appearance of imbricating lamellæ resting one under the other from before backward; this feature is only seen on the most perfectly preserved specimens; the surface of the cheeks is slightly granulose under a strong magnifying glass, and has slightly irregular lines which radiate from the base of the eyes and glabella out to the marginal rim; the surface of the segments of the thorax shows a fine tracery of inosculating, undulating striæ subparallel to the segment, crossing the axial lobe and extending out to the extremities of the pleural lobes. The surface of the telson is not preserved so as to show its characters. The test itself is very thin and fragile, and is usually broken away.

The above description is that of what is considered as the normal adult type and omits altogether the phases of this remarkable species that are shown in its various stages of growth and development. The relation of this species to *Olenellus Thompsoni* are very intimate in what I called the normal adult type, but when we study it in all its details it appears best to consider the western form as representing a distinct species.

The form of the pleural lobes of the third segment is frequently like that of the corresponding segment in *Mesonacis Vermontana*; it is there broad and nearly straight from the outer angle to the spinose termination of the pleura; in other individuals it is more narrow, rounded on the genal angle, and curves gracefully outward and backward to the long, slender points, as in some examples of *M. Vermontana*.

The largest head yet observed has a length of 6^{cm} and a width of 12^{cm}. Comparing this with a smaller entire individual, we find that the animal to which the large head belonged had a length of over 14^{cm}, exclusive of the elongate telson, which was from 6^{cm} to 8^{cm} long if proportionate to that of the smaller individual.

The original specimens upon which the two species *O. Gilberti* and *O. Howelli* were based were collected at Pioche, Nevada, by Mr. Edwin Howell, of the Wheeler Survey.

Formation and localities.—Middle Cambrian. The species occurs in limestone and argillaceous and sandy shales, and ranges through from 50 to 300 feet of strata overlying a massive belt of reddish-brown quartzite that is 3,000 feet thick in the Wasatch Mountains. In Nevada *O. Gilberti* has been found at Pioche on both sides of the anticlinal arch of quartzite; on the western side of the Highland Range, 8 miles north of Bennet's Spring; in the Groome District, near the south end of Timpahute Range, on Silver Peak, longitude 117° 20′ west, latitude 38° north; and on the summit of Prospect Mountain, Eureka District. In Utah two localities are known: one in the cañon just above Ophir City, in the Oquirrh Range, and the other in Big Cottonwood Cañon, Wasatch Mountains, one mile below Argenta. The specimens brought in from Kicking Horse Lake, British Columbia, by Mr. George M. Dawson, appear to be identical with those from Nevada and Utah.

OBSERVATIONS ON OLENELLUS GILBERTI.

Under the title of "Observations on *Olenellus Howelli*" (Monographs U. S. Geol. Survey, vol. viii, p. 32), I have attempted to describe the remarkable series of variations observed in the head of this species during several stages of growth. Additional material has since been obtained, and the principal facts are here brought together.

Unless otherwise mentioned, all the specimens are from the same stratum of rock.

Contour of the head.—The smallest specimen of the head observed, fig. 1*c*, pl. xx, is 2.5^{mm} in length, and resembles in its outline the larger head, fig. 1*e*, which has a length of 7.5^{mm}, which is seen more clearly by comparing the latter with the enlargement of fig. 1*c*=fig. 1. Between figs. 1*c* and 1*e*, in size, is the form represented by fig. 1*d*, which is transversely quadrilateral in outline, with the genal angles and spines carried forward to form antero-lateral angles on a line with the frontal margin of the head; and the geniculation of the posterior margin, which is so strongly marked in fig. 1, is still further increased to form an angle of nearly 90°, which, from its position, might be incorrectly viewed as the true genal angle if the anterior spines were broken away or obscured and the course of development of the species unknown. In fig. 1*g* the genal spines are still more anterior than in the smaller forms (figs. 1*c* and 1*e*), and present a transition stage—not considering the size of the head, but the general form—between figs. 1*c* and 1*d*, or 1*d* and 1*e*; the angles of the posterior margin *xx* are also more obtuse, and the frontal margin broadly rounded. Through the forms represented by figs. 1*e*, 1*g*, 1*h*, the modification of these features is very uniform to the normal adult type of the contour of the head, as shown by fig. 1*i*. In figs. 1*m* and 1*k*, however, which are considerably larger specimens, the angularity of the posterior margin is a prominent feature, the genal angles being advanced as in the forms before fig. 1*i*. In fig. 1*l* the outline is still further diversified by having the angularity of the posterior margin and the position of the genal spine on one side different from the other side. Fig. 1*i* is considered as nearly typical of the adult outline of the head as the largest specimen found, and a number of medium size have the same form, and it is characteristic of other species of the genus.

The geniculation of the posterior margin is an embryonic character that is singularly persistent in many examples that have otherwise adult characters. In fig. 3*b* the adult form of the head of another species of the genus is shown.

The specimen represented by fig. 1*f* is from the south end of the Timpahute Range, 200 miles south of the Eureka district. It is associated with such forms as 1*c*, 1*e*, and 1*i*, and also with *O. Iddingsi* on the same slab of limestone. It has the genal spines even more anterior than in fig. 1*d*. With it occurs the form on plate xix, fig. 2*d*, which, in the position of the glabella, is much like the typical *O. Gilberti* of Meek. One other specimen of the head that is 3^{mm} in length has the outline of fig. 1*g*, and three others, having a length of 2^{mm}, 1.8^{mm}, and 1.5^{mm}, respectively, have a contour as shown in fig. 2*c*, pl. xvii.

Glabella.—In the smallest head the glabella is depressed between the large crescent-shaped eyes, and the anterior lobe appears to be a link uniting the anterior portions of the two eyes to form a semicircle around the depressed glabella back of its anterior lobe; in succeeding stages of growth the glabella rises and expands in front, as shown in fig. 1 of plate xx. Comparing with the glabella of the adult, it is to be observed that in the younger individuals the glabellar furrows extend entirely across the glabella, while in the older ones they are more or less interrupted or united only by very shallow transverse furrows at the center, and that the frontal lobe of the glabella is more expanded proportionally in the young forms.

Eyes.—The usual form of the eye of the adult of this genus is shown by the eye of *O. Thompsoni*, fig. 9, plate xvii.

In the youngest stages known to us of the head of *O. Gilberti*, 1.5mm in length, the eyes are very large and elevated above the glabella and are the most prominent feature of the head; on a larger head, 2mm in length, they still predominate, but in a head 3mm long they are situated a little distance from the glabella toward the center of the cheek and united to the anterior lobe of the glabella by a strong, elevated, ocular ridge that crosses and interrupts the continuity of the dorsal furrow (see figs. 1, 1*b* and 1*f*, pl. xx). There is considerable variation in the relative position of the eye and the length and strength of the ocular ridge in different examples of the head. In fig. 1*d* the ocular ridge of the left side is elevated, and, with the high margin of the eye lobe, partially incloses the depressed area within, while on the right side of the same individual both the ridge and eye are less elevated, and, the ocular ridge being shorter, the eye is brought in nearer to the glabella. In fig. 1*g* the ocular ridge is narrower at the point of union with the glabella and attached farther back, near the posterior margin of the frontal lobe. Frequently the longitudinal axis of the eye is slightly oblique from its anterior end backward and outward. With the increase in size, these features usually disappear, although in fig. 1*i* there is an exception, as they are retained in a modified degree after other accompanying embryonic features of the head have disappeared. Between the eye and the glabella, when the former is situated well out on the cheek, a small round or oval boss occurs, as shown in figs. 1*d*, 1*e*, 1*g*, and 1*i*.

Facial suture.—The course of the facial suture in front of the adult head is shown by the free cheek, fig. 1*c* of plate xv. Of its variation from this course during the development of the individual nothing is known from actual observation, but, from the fact that the relative position of the eye changes, it is probable, indeed almost certain, that its direction is somewhat varied, and we know that such is the case in its direction back of the eye when the latter is situated on the cheek or near the glabella. Back of the eye, in all the instances in which it has been observed, its direction is slightly outward, with a sigmoidal curvature to the angle of the posterior margin, or, in its absence, to the broad curve denoting the position of the angle about midway between the dorsal furrow and the genal angle, figs. 1*e*, 1*g*, 1*h*, and 1*i*, pl. xx. In the large adult specimen its course was probably as indicated by the traced line in fig. 1*l*, where it is much the same as in the genus Ogygia or Dicellocephalus, and even more so in the cheek, fig. 1c of pl. xviii, if it cut the posterior margin at the angle x, as it does in all known cases in the smaller specimens, figs. 1*h* and 1*i*. Comparing this with the direction of the stages of growth shown on figs. 1e and 1*g*, where another generic group is suggested by its Paradoxides-like course, the contrast is very striking.

It is stated on p. 34, Monographs United States Geological Survey, vol. viii, that in adult specimens of *O. Gilberti* and *O. Vermontana* the course of the facial suture is almost directly backward from the eye to the margin. This statement was based on the published figures of the two species. I now have before me the type specimens of *O. Gilberti*, and I fail to find a trace of the facial suture showing on any one of them, and their course is not mentioned by either Mr. Meek or Dr. White, the artist evidently having indicated in the drawings his personal views of where they should be placed.

In well-preserved specimens of *O. Thompsoni* the suture back of the eye extends outward to the pleural angle, as in *O. Gilberti*.

Mode of development.—The normal development of a trilobite from the earliest embryonic condition with which we are acquainted to the adult form is marked by the disappearance of the embryonic characters, one by one, as the individual increases in size and assumes more and more the features of the fully developed animal, all of which usually takes place, except in size and surface ornamentations, when it is quite small. The retaining of an embryonic feature after the individual has passed in size, or in any other character, the stage at which it usually disappears in the regular course of the development of the species is an exceedingly rare occurrence, and is unknown to our knowledge, except in the increase in size of the body in certain species, so that in their course of development certain individuals are in fact larger than those of the same species having a greater number of segments in the thorax and being consequently more advanced in development. M. Barrande has shown this to be the case in the development of *Arethusina Konincki*, *Proetus decorus*, and *P. venustus* (Syst. Sil. Bohême, i, p. 268, 1852), and we have observed it in *Triarthrus Becki*, where the relative size, proportional to the development, is very marked; e. g., an individual with thirteen segments in the thorax is 24^{mm} in length, and one with sixteen segments but 16.5^{mm} long, while the fully grown example of sixteen segments reaches a length of 53^{mm}, and some with thirteen segments are but 7^{mm} in length (Trans. Albany Inst., x; Fossils of the Utica Slate, p. 29, 1879).

This peculiarity of growth is shown, in the species mentioned, only by the thorax, for, if we take the head alone, there is little or nothing to prove that its size is not proportional to the stage of development; but in *Olenellus Gilberti* the head proves this to be otherwise, and there may be added to the statement that, in certain species, the size is not proportional to the number of liberated segments in the thorax, that in this species the size of the head is not always proportional to its stage of development.

The smallest specimen we now have (it is doubtfully referred to this species) is 1.5^{mm} in length; but, owing to its having been exposed to atmospheric action, the details of its surface are not well preserved; the general form and the prominent eyes, narrow glabella, and depressed margins are all that can be satisfactorily determined; these are shown in fig. 2*c*, pl. xix.

The course of development would appear to have been from some such form as this through forms similar to those represented by figs. 1*c*, 1*e*, 1*h*, and 1*i*, plate xx, but we find forms like figs. 1*d*, 1*f*, and 1*g* associated with the former forms, in the same pieces of rock, at localities 125 miles distant from each other, and there is in each locality a gradation of form uniting such extremes as figs. 1*f* and 1*i*. Separating the two extremes, as two species, will solve the difficulty of giving a common origin to such forms as figs. 1*c*, 1*d*, 1*e*, 1*f*, 1*g*, 1*h*, and 1*i* represent, but we cannot obtain evidence to warrant such a separation. Both at Eureka and in the Timpahute Range, the evidence is strongly in favor of referring all the variable forms of the head to one species.

It is observed that figs. 1*m*, 1*k*, and 1*l* precede 1*i* in the stage of development of the contour of the head, at the same time showing a more accelerated development in the form of the eye. The eye of fig. 1*h* is more advanced than that of fig. 1*i*, while the posterior outline of the head is more embryonic in its character. With these examples it is readily conceived that figs. 1*d*, 1*f*, and 1*g* are large forms that preceded fig. 1*c* in development, and the eye of fig. 1*d* supports this view, as it is, in its strongly developed ocular ridge which is more marked than in fig. 1 and more anterior in relation to the frontal lobe of the glabella, essentially more embryonic; and the position of the genal angles and spines is either a decidedly embryonic feature or such a sport as, with fig. 1*a* to connect it with figs. 1*c* or 1*e*, would not be considered probable.

From the material now at our command I think that the earlier form of the young was similar to that of fig. 2*e*, pl. xix, and that the characters of the head at the stage of development represented by fig. 3*a*, pl. xx, of *O. asaphoides* were permanently retained by many individuals until reaching adult size, or that such forms as figs. 1*e*, 1*e*, 1*g*, 1*k*, 1*l*, and 1*m* represent the stage of development passed through in the usual growth of the young of *O. asaphoides* and *O. Gilberti* before reaching the size of fig. 1*c*, and that what is a transition stage in *O. asaphoides* (fig. 3*a*) is often extravagantly developed and becomes a fixed stage in a large proportion of the individuals of *O. Gilberti*.

Relations to other species and genera.—The difficulty met with in comparing the development of this species with that of other species in which the thorax and pygidium are known, is also felt in studying its relations to various species and genera in which the structure of the entire body is known, as we have but few entire individuals and but one shows embryonic characters.

The heads of the species associated with *Olenellus Gilberti* and *O. Iddingsi* are small, but they do not present any recognized embryonic features.

As already stated, the suture lines shown for *O. Gilberti* are purely imaginary in the type figures (Geog. and Geol. Surv. West 100th Merid., vol. iii, pt. 1, pl. ii, figs. 3*a–c*), and their course is, in all probability, as in other species of the genus.

Mention has been made of *Olenellus asaphoides* and of certain resemblances in the contour of its head at the stage of development represented by fig. 3*a*, pl. xx, and that of the head of *O. Gilberti* as seen in figs. 1*c*, 1*e*, 1*h*, &c. The curious interocular spines of the former have not been seen in *O. Gilberti*. Mr. Ford has called attention to the Paradoxides-like run of the posterior margin of the head, *g x*, *x g*, fig. 3*a*, and states that it disappears altogether during the embryonic life of that species. We have shown that it is extravagantly developed in *O. Gilberti*, even to the extent of changing the entire contour of the head, figs. 1*d*, 1*f*, and 1*g*, and that it persists in the adult stage of many individuals of this species, and is also present in *Mesonacis Vermontana*.

In all the observed specimens of *O. Gilberti* showing the facial suture back of the eye, the posterior margin is cut at the angle within the postero-lateral angle, as Mr. Ford has pointed out for the form, fig. 3*a*, of *O. asaphoides*, and also for the genus Paradoxides.

Attention is again called to the direction of the facial suture back of the eyes in figs. 1*e* and 1*g* and the position and obliquity of the eyes in relation to the median line of the glabella, characters of Paradoxides, as seen in *P. spinosus*. Of all the species of the latter genus, *P. Kjerulfi* (Öfversigt k. Svensk. Vet.-Akad. Förhandl. N:o 6, p. 790, Tafl. xvi, figs. 1, 2. Stockholm, 1871) alone shows the presence of an ocular ridge uniting the eye and the frontal lobe of the glabella (fig. 2, pl. xx), a feature so prominent in the young of *O. Gilberti*, as well as the small rounded protuberance between the eyes and the glabella, shown in Linnarsson's fig. 2 of *P. Kjerulfi*. The latter character Mr. Ford discovered in the young of *O. asaphoides*, and noted its resemblance to the same in *P. Kjerulfi*. The ocular ridge, a feature in the latter that is permanent, is also present in the young and adult of *O. Gilberti* and in *O. Thompsoni*.

Résumé.—The study of the head of *O. Gilberti*, proves:

First. That in certain individuals of this species the existence of embryonic features continues long after the individual has reached the size at which such features are usually lost in the process of development of the other species of the genus.

Secondly. That, in individuals otherwise developed equally in all respects, some one of them may have a characteristic feature, such as the eye or the genal angle developed to a greater or less degree than in the others, and that this feature may persist even after the individual having it has passed in size or other characters the stage at which it is usually lost.

Thirdly. That the development of certain characters is present in an unequal degree in the corresponding parts of the same individual.

Finally, that certain features present in the younger individual and disappearing during subsequent growth are permanent features in some species of the genus Paradoxides.

To the biologist this species has a peculiar interest, as we appear to have the remains of an animal that was approaching extinction and gradually losing its vital force to such an extent that the young were unable to develop to the adult form except in a more or less imperfect degree, and, as a result, retained embryonic features although having the power to grow to the adult size. In only a comparative degree can we say that it is a case of reversion to the original forms of the genus or family to which it belongs, as we know so little of the progenitors of the Paradoxides. That certain characters of Paradoxides are present in the young of *Olenellus Gilberti* that are not present in the adult type of the genus, and that these characters are present in many but not in all adult specimens of *O. Gilberti*, we do know, and to that extent a reversion to the characters of its ancestry is shown in the period approaching the extinction of the species.

During the summer of 1885, the writer visited Pioche and the Highland Range, Nevada, and obtained a large collection of Cambrian fossils, among them severa' entire examples of *O. Gilberti*. One with a length of 25^{mm}, exclusive of the telson, which is quite as long as the body, shows most decided embryonic characters in the head, and the third segment of the thorax has a peculiar form to the pleural lobes and is prolonged to an extravagant length. The form of the third segment is not entirely normal, as it has been crowded forward and the pleural groove depressed. The pleuræ figured on pl. xix, figs. 2*h* and 2*i*, probably belonged to an individual like fig. 2 of pl. xxi.

Another specimen, 30^{mm} in length, exclusive of the telson, pl. xxi, fig. 1, is essentially a young specimen of *Olenellus Thompsoni*, differing less from that species than from the specimen mentioned above. The only reason I have for leaving *O. Gilberti* under a different specific name is the fact of its having such a peculiar and abnormal variation in different individuals.

If the two specimens represented by figs. 1 and 2 of plate xxi were submitted to a paleontologist he would be very apt to consider them not only as specifically distinct, but perhaps refer fig. 2 to a subgenus of fig. 1; and I acknowledge that, in asking the student to consider them as different phases of one species, I am requiring him to accept evidence which is only partially given in the illustrations of the species; but, if he has followed me in the preceding pages of description of *O. Gilberti*, he may understand why the head represented by fig. 1*f* of pl.

xx is regarded as specifically connected with that of fig. 1, pl. xviii, or fig. 1*b* of pl. xx, and that figs. 1 and 2 of pl. xxi are considered to be specifically the same.

There are no differences of the bodies of figs. 1 and 2 of pl. xxi that are essential, except in the third segment of the thorax, as the broad and narrow forms of the figures are owing largely to the specimens having been compressed in opposite directions. The difference in the form of the third segment is of the same type as that in the genal spines of the head.

Fig. 1*a*, pl. xxi, shows the head of fig. 1 natural size. Fig. 2 of pl. xix is evidently the same; also figs. 2*a* and 2*b* of the same plate. With fig. 2*a* of pl. xix the transition to figs. 1*b* and 1*i* of pl. xx is natural, and then from fig. 1*i* of pl. xx to figs. 1*b*, 1*e*, 1*g*, 1*d*, and 1*f*. That this change is not a direct embryonic development is shown by the size of the heads and by the fact that it occurs in heads of nearly the same size, as in the head of fig. 2*a*, pl. xxi, figs 1*i*, 1*l*, 1*m*, pl. xx, and fig. 2*b*, pl. xix.

If we do not accept the view that only one species is represented, and begin to break up the series, the complications that arise are much greater than the acceptance of one variable species, abnormal in its growth, as already described.

The spines of the head of fig. 2 of pl. xxi are of the same type as those of fig. 2*d* of pl. xix and 1*f* of pl. xx. If there is a specific difference between figs. 1 and 2, pl. xxi, it is in the length of the genal spines, as we have specimens with the long spines showing the variation in the outline of the head from fig. 1*f*, pl. xx, to a head of the same outline as the head of fig. 1, pl. xxi. In fact, fig. 1 of pl. xx is more nearly related to fig. 2 of the same plate, in respect to the strength of the spines, than to the average head of the species. With all the data that I can obtain, I think that we have but one species now placed under *O. Gilberti.*

Genus OLENOIDES Meek.

Olenoides Meek, 1877. Geol. Expl. Fortieth Par., vol. iv, pt. 1, p. 25.
Type *Paradoxides? Nevadensis* Meek, 1870. Proc. Acad. Nat. Sci. Phila., vol. xxii, p. 62.

The generic description is drawn from the type species and the second species, *O. typicalis.*

General outline ovate. Head large, semicircular. Glabella straight or slightly expanded in front; marked by three pairs of furrows in *O. typicalis.* Eyes elongate. The facial sutures extend obliquely outward from the anterior base of the eyes and cut the frontal margin; posteriorly they cut the margin at the pleural angle and run subparallel to the margin, to the posterior end of the eye.

Thorax with eight or more segments; axis strong and pleural lobes well defined; pleural groove broad.

Pygidium marked by transverse furrows on the axis, and the lateral segments are directed backwards.

The genus is referred to the family Paradoxidæ. It is a type unlike Paradoxides, Olenellus, or Dicellocephalus, and yet includes in its thoracic segments features common to the two former genera and, in the eyes and facial sutures back of the eyes, characters found in Dicellocephalus.

The stratigraphic position of the species referred to it, *O. Nevadensis*, *O. typicalis*, *O. spinosus*, and *O. flagricaudus*, is between the Middle Cambrian (Olenellus) horizon and Upper Cambrian (Dicellocephalus) horizon.

The type specimen of *O. Nevadensis* preserves the occipital segment of the head, the eight thoracic segments, and about two-thirds of the pygidium. The second species is known by its entire form and is referred to the genus from having a similar type of thoracic segment and a pygidium, so far as is now known, of the same type. I had described and proposed a generic name for *O. typicalis*, but, on discovering that Mr. Meek had proposed the name Olenoides for a species that, so far as known, could be generically associated with *O. typicalis*, I adopted the name, being placed in the dilemma of having a species with a generic name proposed "in case *it might* be found to be a distinct generic type," to which to refer the species, or of giving a new generic name that, on finding more perfect material of *Paradoxides? Nevadensis*, might prove to be congeneric with the latter. To avoid introducing a new name that might become a synonym, all the species originally arranged with the species *O. typicalis* are now placed with it under the genus Olenoides.

OLENOIDES NEVADENSIS Meek.

Plate xxv, fig. 7.

Paradoxides? Nevadensis Meek, 1870. Proc. Acad. Nat. Sci. Philad., vol. xxii, p. 62.
Idem, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 23, pl. i, fig. 5.

The original description appeared in 1870 and was reprinted in 1877, the only change being in the proposal of the generic name Olenoides in event of the species proving to belong to an undescribed genus. The later description is as follows: "Of the thorax, eight of the posterior segments are preserved. These show the axial lobe to be much depressed, and about as wide as the lateral ones, exclusive of the free recurved points of the pleuræ. The segments of the axial lobe are defined by a broad, rounded furrow, or depression, across the anterior side of each, and have much the general appearance of those of some species of *Paradoxides*, being a little thickened, squarely truncated, and slightly curved forward at the ends. But they differ in showing distinct remains of a mesial spine, or tubercle, on each, and in having an obscure, oblique furrow, or depression, on each side, passing outward and backward from the broad, anterior, transverse furrow to the posterior lateral angles, so as partly to isolate the slightly-thickened and truncated extremities of each. The lateral lobes are nearly flat and composed of pleuræ that extend straight outward at right angles to the axis to their free extremities, which are abruptly contracted (almost entirely on the posterior side) into slender, rounded, very sharp spines, which curve backward and outward. Each of the pleuræ is also provided with a broad, rather deep, flattened furrow, which commences near the inner end and extends straight outward for some distance, with parallel sides, but gradually tapers, mainly on the anterior side, to a lanceolate point, before reaching the free extremities. These furrows have not the obliquity usually seen in those of *Paradoxides*, but run parallel to the direction of the pleuræ, so as to leave a slender straight ridge of equal size along the anterior and posterior margin of each rib.

"The pygidium, exclusive of the portions of the free border broken away, has a nearly semicircular outline, being about twice as wide as long, while it is as much flattened as the thorax. The part remaining equals in length the five thoracic segments next in advance of it. Its mesial lobe is much depressed and about three-fourths as wide anteriorly as the breadth of that of the thorax at its widest part seen. Posteriorly it tapers moderately, and extends nearly the entire length of the pygidium, as seen with the free border broken away. It is evident, however, that the flattened border projected more or less behind its termination. It shows distinctly five segments, with indications of about two others at the posterior end. The lateral lobes have each three segments, the anterior one being extended out nearly parallel to those of the thorax, while the others are directed more obliquely backward, and rapidly widen outward. Like the pleuræ, they have each a broad, flattened furrow, that of the anterior one being nearly parallel to those of the pleuræ, while those of the other two are directed more obliquely backward, particularly the posterior one, which is almost parallel to the longitudinal axis of the body. These furrows are so deep and broad as to give the three segments of each lateral lobe the appearance of six irregular ridges, the irregularity being produced by the posterior two furrows, instead of passing along the middle of each segment, being curved backward so as to divide it very unequally, leaving the anterior part much the broader. No fine surface-markings are preserved on the specimen.

"Entire length of the imperfect specimen, nearly 3 inches, of which the remaining eight thoracic segments form 1.70 inches; breadth of the thorax, exclusive of the free spiniferous ends of the pleuræ, 2.05 inches, and, including the projecting ends of the pleuræ, 2.40 inches; length of what remains of the pygidium, 1.03 inches; breadth of the same, about 1.80 inches.

* * * * * * *

"It is possible I should call this species *Olenus* or *Parabolina Nevadensis;* but its large size seems to be an objection to placing it in any section of either of these groups. In the possession of a node or spine on each of the thoracic segments, as well as in the direction of the posterior segments of the lateral lobes of the pygidium, it agrees with the type of *Parabolina;* but, unfortunately, the specimen is not in a condition to show whether or not these segments of the pygidium terminated in produced marginal spines, while the furrows of its pleuræ have not the obliquity of those seen in that type, but agree more nearly with those of some species of Conocoryphe. The comparatively large size of its pygidium, and the nodes, or spines, on its thoracic segments, as well as the nature of the furrows of the pleuræ, are rather against its reference to *Paradoxides*, and lead me to think that it may belong to an undescribed genus; if so, it might be called *Olenoides*."

Formation and locality.—Middle Cambrian. Bluish-gray calcareous shale, House Range, Antelope Spring, Western Utah.

OLENOIDES TYPICALIS n. sp.

Plate xxv, figs. 2, 2*a*.

Form ovate. Head large, semicircular in outline. Glabella elongate, not quite twice so long as wide; sides subparallel; front broadly rounded; general surface moderately convex and marked by four pairs of glabellar furrows that extend about one-third the distance across, the anterior being scarcely discernable in most specimens; occipital furrow well defined; occipital ring strong, not very convex, and with a rather strong central spine projecting backwards over the thorax.

Fixed cheeks broad inside the rim of the eye, contracted at the front of the eye and expanding to unite with the frontal limb, which is of medium width, concave, and bordered by a narrow, rim-like margin; postero-lateral limbs narrow, elongate, with a central longitudinal ridge and a rather long spine extending backward just within the extremity of the limb. Free cheeks large, bordered exteriorly by a rather thick rim that is produced into a strong genal spine. Eyes narrow, elongate, reaching from opposite the third pair of glabellar furrows back nearly to the posterior margin, conforming in direction to the eye of *Paradoxides rugulosus.*

Hypostoma elongate, strongly convex, broadest anteriorly, narrowing towards the front; a sulcus, that rises on the lateral margin, separates a narrow posterior lobe; two small lateral depressions, or muscular impressions, occur a little in advance of the sulcus; anterior wings small; frontal margin broadly rounded. The hypostoma is more like that of Ptychoparia than that of Paradoxides, Olenellus, or Dicellocephalus.

Thorax with nine segments; axial lobe convex, broad, and tapering very gradually towards the pygidium; a furrow crosses obliquely from each posterior side of the segment and almost unites before the base of a short spine that originates at the center of each segment and extends upward and backward. The spine on the eighth segment is prolonged and extends back quite a distance beyond the extremity of the terminal spines of the pygidium. An individual 15mm long shows the spine with a length of 10mm. The spine is crushed down on the body, but appears to have been slender and curved up and back in a manner similar to that on the sixteenth segment of the thorax of *Cyphaspis Burmeisteri* Barrande. (Syst. Sil. de Bohême, vol. i, pl. xviii, fig. 62.) The body of the pleural lobes is narrow, and each pleura is extended in a long spine; pleural groove short and nearly as broad as in the genus Olenellus.

Pygidium subquadrangular; median lobe obconical, convex, divided into three segments and a terminal portion; lateral lobes formed of three segments directed backward, terminating in sharp points and gradually decreasing in size backward.

Surface finely granulose; radiating venulose lines ornament the palpebral lobes and free cheeks, and longitudinal striæ the genal spines and spinous extension of the pleuræ.

The specimen figured has all but the free cheeks in position; these were drawn from a smaller specimen.

The general form of the pygidium is similar to that of one figured by Mr. Billings (Pal. Foss., vol. i, p. 334, fig. 332*b*), from Point Levis, Canada, where it was associated with Upper Cambrian fossils, and it may be that when entire specimens are found some of the species referred to Dicellocephalus, from the same bed and locality, will prove to belong to this genus.

Formation and locality.—Middle Cambrian. In a light pinkish-colored shale above a belt of limestone resting on the shales carrying *Olenellus Gilberti*, Pioche, Nevada.

OLENOIDES SPINOSUS Walcott.

Plate xxv, figs. 6, 6*a*.

Ogygia? spinosa Walcott, 1885. Monographs U. S. Geol. Survey, vol. viii, p. 63, pl. ix, fig. 22.

The original specimen preserves only the central portions of the head within the free cheeks. The glabella resembles that of Ogygia, so a provisional reference was made to that genus.

The discovery of *O. typicalis* gives the generic reference and a second specimen of the same parts of the head from the arenaceous shales at the same relative geologic horizon at Pioche affords details not shown in the Eureka specimen. The glabella is expanded more in front and the postero-lateral limb is preserved; no trace of the occipital spine is shown, but this was probably carried away with the test. Four pairs of glabellar furrows occur, instead of three, as mentioned in the original description.

Formation and localities.—Middle Cambrian. At the base of the Secret Cañon shale, in Secret Cañon, Eureka Dictrict, Nevada; also, at Pioche, Nevada, in arenaceous shale interbedded in argillaceous shale; National Museum collection.

OLENOIDES? FLAGRICAUDUS White.

Plate xxv, fig. 4.

Dicellocephalus? flagricaudus White, 1874. Geog. and Geol. Expl. and Surv. West 100th Merid., Prelim. Rep. Invert. Foss., p. 12. *Idem*, 1875. Same report, vol. iv, pt. 1, p. 60, pl. iii, fig. 8*a*, *b*.

Original description.—"Pygidium contracted, fan-shaped; lateral lobes each consisting of three segments directed backward; the inner one of each side lying close to the dorsal furrow, nearly parallel with the axis of the body or converging a little posteriorly, and becoming obsolete upon each side of a small, but comparatively wide, sloping border that extends around the posterior end of the axial lobe.

"The middle pair of segments commence at the dorsal furrow of each side respectively, near the anterior end of the pygidium, bend abruptly, and extend backward parallel with the first, and project beyond the border as converging posterior spines. The third and outer pair of segments commence anteriorly at the dorsal furrows, where they are very narrow, extend outward a little, then curving abruptly backward they lie parallel with the others and form raised lateral margins of considerable but unequal width to the pygidium, and thence they extend posteriorly as an outer pair of converging spines. Axis prominent, especially at its apex, where it terminates in a moderately distinct angle, about one-quarter wider anteriorly than posteriorly, well defined by the nearly straight dorsal furrows, and marked by five or six distinctly defined segments, which cross it almost transversely, but with a slightly sinuous course.

"Length of the pygidium along the median line, 7^{mm}; greatest transverse diameter, 9^{mm}.

"The collections contain only the pygidium of this species, and I have therefore referred it doubtingly to *Dicellocephalus*, although it might perhaps, with equal propriety, be referred to *Amphion*. It has a general resemblance to the pygidium of *D. magnificus* Billings, and a still closer resemblance to *D.? Corax* Billings, from the Quebec group of Canada.

"*Position and locality.*—Strata of the age of the Quebec group of Canada. Schellbourne, Schell Creek range, Nevada."

The species is referred to the Quebec group; but without a better knowledge of the stratigraphy than we have, and also of the associated fossils, it is difficult to locate the exact horizon, and I suspect that further investigation will place it in the Cambrian.

The generic reference is made entirely on the form of the pygidium.

OLENOIDES ? MARCOUI Whitfield.

Plate xxvi, figs. 5, 5*a*, *b*.

Dikellocephalus ? Marcoui Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. 1, p. 150, pl. xiv, fig. 7.

Original description.—"This species is only known, as yet, from fragments of the pygidium, but the form is so remarkable for a primordial trilobite and so distinctive in its characters that it will be readily recognized in other specimens when found; consequently there can be no good reason why it should not be described even from the imperfect material.

"The pygidium has been broadly fan-shaped, with a strong central axis, and broad convex lateral lobes; form nearly semicircular, with a moderately convex anterior margin. Axial lobe about two-thirds as wide as each lateral lobe, strongly convex, marked by about nine or possibly ten annulations (seven appearing in the fragment), the anterior three each bearing an elevated node or subspine in the middle, the fourth one having only a low node, the remainder plain. Lateral lobes divided into five or more annulations, exclusive of the narrow anterior one, by deep narrow grooves or furrows, which terminate a little within the border; each annulation being marked on its surface by a faint, depressed longitudinal line. Outer margin of plate bearing broad flattened spines, which are gently recurved. Five of these spines are seen on the fragment described, the last of which originates opposite the fourth segment, leaving space for two or perhaps three additional ones between it and the central line of the plate. This would give seven or possibly eight spines on each side of the plate. Surface of the plate smooth to the unassisted eye.

"This is one of a group of primordial trilobite pygidiæ having affinity with the genus Dikellocephalus Owen, but not properly belonging there. They have been variously placed under several genera, but are equally unlike any of them, and this one is more extreme in its characters than any hitherto described. It strongly reminds one of the pygidiæ of a group of *Dalmania* which characterize the Lower Devonian of America, in the arrangement of spines around the outer margin, and is so very similar that were there any question as to its authenticity I should have been inclined to place it at that horizon."

In all the collecting done at the Parker quarry the past two years only a few pygidia of this species have been found, and but one imperfect head, and nothing is known of the thorax.

The head and pygidium do not belong to the genus Dicellocephalus, and the pygidium, in its spinose extension of the segments, approaches the forms we have referred to Olenoides.

The reference to Dicellocephallus is misleading, as the genus is typical of the Upper Cambrian or Potsdam horizon and is as yet unknown in the Middle Cambrian.

A similar type of the pygidium is figured by Angelin (Pal. Scan., pl. xxxiii, fig. 11) and doubtfully referred to the genera Corynexochus. In Brögger's Die silirischen Etagen 2 und 3, pl. i, a number of pygidia with a spinose border of this type are referred to the genera Peltura.

Formation and locality.—Middle Cambrian. Parker's quarry, town of Georgia, Franklin County, Vermont; also, in the conglomerate limestones of Bic Harbor, on the St. Lawrence River, below Quebec, Canada.

OLENOIDES LEVIS n. sp.

Plate xxv, figs. 3, 3*a*.

Of this species we have only the head within the facial sutures. The glabella is elongate, sides parallel, front broadly rounded, general surface moderately convex and marked by glabellar furrows. Occipital furrows well defined, occipital segment imperfectly preserved, but apparently narrow. Free cheeks broad; the rim of the large eye lobe is continued across the cheek to form the ocular ridge; frontal limb narrow concave and rising rapidly from the front of the glabella to the narrow frontal rim; laterally it merges in the broad, free cheeks; postero-lateral limbs broken away except the inner portion on the left side, which is narrow, as in *O. typicalis*. Although imbedded in limestone the surface is not well preserved; it was probably smooth or finely granulose.

In the form of the glabella and broad, fixed cheeks this species differs from other known species of the genus.

Bathyurellus abruptus Billings (Pal. Foss., vol. i, p. 263, fig. 247) is of this type of head, and is placed as the first species after the generic description, but it is evidently not regarded as the type of the genus Bathyurellus, as the generic description is taken from the species *B. nitidus*, described after *B. abruptus*.

This species occurs in a granular limestone with *Olenellus Gilberti*. At a higher horizon *Olenoides spinosus* is found in an arenaceous shale, and still higher in the section *O. typicalis*, in an argillaceous shale.

Formation and locality.—Middle Cambrian. Pioche, Nevada.

OLENOIDES QUADRICEPS H. & W.

Plate xxix, figs. 1, 1*a–c*.

Dikellocephalus quadriceps Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 240, pl. i, figs. 37–40.

Dicellocèphalus ? quadriceps Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 45, pl. ix, fig. 24.

Original description.—"Glabella and fixed cheeks united, quadrangular in form, with a regularly and symmetrically arcuate front margin. Glabella elongate quadrangular, a little expanded and rounded in front, three-fourths as wide across the middle as the length above the occipital furrow, very gibbous or somewhat inflated; marked by three pairs of transverse furrows, which extend about three-fourths of the distance to the center, not in the least oblique, and so faint as to be detected only on the closest examination or by the reflection of light along the surface; occipital furrow very distinct; ring strong and robust, supporting a strong, thickened spine of undetermined length on the posterior margin. The base of the spine is broad and the spine directed backward and upward.

"Fixed cheeks of moderate size, strongly convex, a little more than one-third as wide at the eye as the width of the glabella, and rapidly declining to the antero-lateral angles. Eye-lobe small, situated rather behind the middle of the length of the head; ocular ridges distinct, strongly directed forward in their passage from the eye to the glabella. Frontal limb very short, not extending beyond the frontal margin of the glabella, and strongly curving backward to the point of intersection with the facial sutures.

"Facial sutures commencing at the anterior margin on a line with the inner angle of the eye-lobe, and running directly back to the eye in a straight line; behind the eye the direction is outward, but its exact course has not been ascertained. Lateral limb not observed.

"A pygidium associated with the glabella is paraboloid in form, and surrounded on the margins by twelve short, rather strong spines, the four on the posterior margin being shorter than the others. Axis narrow, highly convex, two-thirds as long as the shield, and marked by four rings, exclusive of the terminal ones. Lateral lobes broad, convex, and marked by four low, rounded ribs, the anterior one much narrower than the others; each of the four ribs terminating in one of the lateral spines.

"There can be no doubt that the above-described pygidium belongs to the same species with the associated glabella, as they are both equally abundant and are the only trilobitic remains brought from the locality, except those of *Conocephalites subcoronatus*. The glabella is enlarged to three diameters in the figure, while the pygidium is given natural size, but is one of the largest individuals seen, while there are fragments of glabellas in the rock fully twice the size of the specimen figured. The species bears a very close resemblance to *D. gothicus* herein described, but differs principally in the simple ribs; while in that species they are divided, a feature that will very readily distinguish the two forms.

"*Formation and locality.*—In limestone of the age of the Quebec group, from the base of Ute Peak, Wasatch Range, Utah. Collected by Arnold Hague, esq."

There is little doubt of the generic relations of *O. quadriceps* with Olenoides, and it occurs at the same relative geologic horizon in the Eureka district, and, from all I can learn of the locality on Ute Peak, its position there is at the same relative horizon as *O. Wahsatchensis*, which we know to be Middle Cambrian and below the Potsdam fauna. The reference of the species to the Quebec group shows the confusion then prevailing as to the paleontologic characters of a group named, but not existing, as defined by its authors, in nature.

The head and pygidium are of the same type as *O. Marcoui* and *O. Wahsatchensis*.

The differences between the head of this species and that of *O. Wahsatchensis* are not of specific value, and, except that the latter species shows in the pygidium strong pleural grooves, I would unite them as one species. This character is slightly shown in some of the pygidia of *O. quadriceps*, and it is not improbable that the specimens in the shales develop these grooves much more distinctly, owing to the crushing of the test and consequent deepening of all the original depressions. A good series of specimens may yet prove the two species to be identical.

Formation and localities.—Middle Cambrian. Ute Peak, Wasatch Range, Utah, and on the east slope of Prospect Peak, Eureka district, Nevada, 4,000 feet below the typical Potsdam fauna, with *Olenellus Gilberti*, &c. A head apparently identical occurs 2,000 feet higher in the section. The other locality, on the west side of the Eureka district, is an outlier of limestone, the stratigraphic relations of which are not known.

OLENOIDES WAHSATCHENSIS H. & W.

Plate xxix, figs. 2, 2*a*.

Dikellocephalus Wahsatchensis Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 241, pl. i, fig. 35.

Dikellocephalus ? gothicus Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 242, pl. i, fig. 36.

Original description of the head.—"Glabella elongate-quadrangular, with parallel lateral margins and slightly-rounded front; height and width about as four to three; very depressed convex, and marked by two pairs of transverse furrows, which do not quite meet in the center, dividing the glabella into three nearly equal portions. Occipital furrow narrow, not strongly defined; ring narrow, distinct, and bearing a slender spine on the center; dorsal furrows narrow and poorly defined.

"Fixed cheeks wide and flattened; ocular ridges faintly marked, rising opposite the anterior furrow of the glabella, and directed slightly backward to the eye-lobe. Frontal limb very short and wide, the marginal rim regularly arcuate, narrow, and prominent, closely cutting the front of the glabella. Facial sutures not fully determined, but are distinct on the anterior margin, cutting the rim with a strong outward curvature, and again recurving to the eye, leaving the limb nearly two-thirds as wide at its widest point as the glabella."

The associated pygidium is described as another species; but, from the character of the head and pygidium of *O. quadriceps* and *O. Marçoui*, I have no hesitancy in referring it to the same species as the head associated with it. The reason given by the authors of the species, that it was not a pygidium characteristic of the genus Dicellocephalus, to which they referred the head, is not accepted, as the head is not typical of Dicellocephalus. A still more cogent reason is the fact that we have a crushed and distorted specimen showing the head, thorax, and pygidium united. The thorax is so badly crushed that only five segments can be counted, and the head and pygidium are partially crushed on each other, owing to the doubling up of the thorax.

Original description of the pygidium.—"Pygidium semi-ovate, or short paraboloid, with a very strong central axis and spinose margin; anterior margin straightened for about two-thirds the width of the lateral lobes, where it curves abruptly backward to the lateral angles. Axial lobe strong, cylindrical, and prominent, forming one-third of the entire width exclusive of the spines, and reaching almost to the posterior margin of the shield; obtusely rounded at the extremity, and marked by six annulations, exclusive of the terminal ones. Lateral lobes very moderately convex, and marked by four divided ribs on each side, each terminating in a strong and proportionally long marginal spine; central area of each rib depressed, forming a flattened groove, extending to the base of the marginal spine. Borders of the ribs elevated, the anterior one strongest and prominent, gradually widening from its origin to the margin of the shield; posterior border narrow and rounded, separated from the next succeeding rib by a sharply-depressed, narrow groove. This peculiar form of rib gives to the shield an appearance similar to the groining of a Gothic arch. Margin of the shield surrounded by twelve long, rather strong spines, four of which, on each side, are about equal in size and strength, while the four occupying the posterior border are shorter and unequal, those in the middle being the shortest.

"The peculiar feature of the specimen consists in the divided ribs of the lateral lobes and spinose margin. In these features it differs from all others known, and may possibly, when better material shall be examined, showing other parts of the organism, require a distinct generic name."

By comparing the figures of *Olenoides Marcoui*, pl. xxvi, figs. 5, 5*a*, with those of pl. xxix, figs. 2, 2*a*, the types of *Dicellocephalus Wahsatchensis* and *D. gothicus*, the generic identity is evident, although the pleural grooves on the anchylosed segments of the pygidium are not known to be present in that of *O. Marcoui*.

The specific relations of *O. Wahsatchensis* are with *O. quadriceps*, as has been mentioned under that species.

Formation and localities.—Middle Cambrian. Box Elder Cañon, above Calls Fort, Wasatch Mountains, and also in Big Cottonwood Cañon, one mile below Argenta, in the same mountains.

Genus BATHYNOTUS Hall.

Bathynotus Hall, 1860. Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 117.
Idem, 1861. Geology of Vermont, vol. i, p, 371.

To the description of the parts given by the author, we are now able to add that of the eye-lobe and the direction of the facial suture. The eye-lobe is narrow, elongate, and extends from opposite the antero-lateral angle of the glabella obliquely backward nearly to the posterior margin, resembling in this the eye-lobe of *Centropleura Loveni* Ang., the type of the genus Centropleura (Pal. Scan., p. 95, tab. iii, figs. 1, 1*a*, 1854), and also the eye-lobe of the genus Anopolenus Salter (Quart. Jour. Geol. Soc. vol, xx, p. 236, 1864; also, note by Dr. Henry Hicks in vol. xxi, p. 477, 1865). The facial suture passes nearly around the extended eye-lobe and cuts the margin before reaching the posterior extension of the eye-lobe. This is another character of the genus Anopolenus. Anteriorly it appears to pass around the front of the glabella and the narrow frontal limb, and, from the fact that the free cheeks are united with the frontal margin, even when detached from the central portions of the head, there is a strong presumption that the sutures pass around in front within the margin without cutting the latter, as in the later genera Phacops and Homalonotus. This is not proven absolutely, but the evidence is very strong in its favor. Number of segments in the thorax, thirteen.

The genus is related to the Paradoxidæ in most of its characters, and is well defined from other described genera.

Dr. Emmons figures, of the typical species, the pygidium, six thoracic segments, and the two large genal spines under the name *Paradoxides? quadrispinosus* (Manual of Geology, 1860, p. 80). In a note on page 280 of the same book, he gives among fossils characterizing the Taconic slates *Paradoxides* (*Pagura*) *quadrispinosus*, mentioning at the same time *Paradoxides Thompsoni* and *P. Vermontana*, which were described by Prof. Hall in 1859 (Twelfth Rep. N. Y. State Cab. Nat. Hist.), at the same time with *Peltura* (*Olenus*) *holopyga*. Why Dr. Emmons failed to note this fact is unknown. It may be that he intended a new genus by placing the name Pagura as above, but, without a description or a reference, I do not think we are warranted in assuming what was meant, and replacing the generic name Bathynotus based on a description and a figure by the name Pagura.

BATHYNOTUS HOLOPYGA Hall.

Plate xxxi, figs. 1, 1*a*.

Peltura (*Olenus*) *holopyga* Hall, 1859. Twelfth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 61; Pal. N. Y., vol. iii, p. 528.
Bathynotus holopyga Hall, 1860. Thirteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 118; Geology of Vermont, vol. i, p. 371, pl. xiii, fig. 3, 1861.
Paradoxides? quadrispinosus Emmons, 1860. Manual of Geology, p. 80, fig. 57. On p 280 the name *P.* (*Pagura*) *quadrispinosus* occurs.

Description.—"Entire form elongate subelliptical, having a length of about twice and a half the width. Head somewhat semielliptical; the posterior angles produced in long spines. Glabella strongly lobed, its length a little greater than its greatest breadth, the entire breadth of the head when entire, being about twice as great as the length. Hypostoma wider than long.

"Thorax with eleven articulations; the middle lobe prominent and about twice as wide as the lateral lobes; the articulations strong, rounded above, and each one marked in the center by a node (or the base of a spine which has been broken off in the specimens examined). Articulations of the lateral lobes short (the extremities of the upper ones broken off in the specimen); the lower ones bending abruptly downwards and terminating in spiniform processes, the last pair being prolonged much beyond the extremity of the pygidium.

"Pygidium longitudinally semielliptical; the middle lobe marked by three annulations, and a fourth obscure one above the terminal lobe; lateral lobes flat and plain, the exterior margin apparently free from ornament or inequality."

In his observations on this species in the Thirteenth Report, 1860, the author adds:

"The rings of the axis are marked by a row of small spines. The greatest length of the spines or processes, from the posterior angles of the cephalic shield, is a remarkable feature. In this individual their extremities must have reached as far as the eighth or ninth segment of the thorax; and in another individual these separated parts have similar proportions.

"In one imperfect specimen of this species, with narrow axis, we have eleven body rings, including the elongated posterior one; but behind this there are three annulations of the axis, the two anterior of which have somewhat the appearance of free segments, and are likewise marked upon the lateral lobes, while the pygidium below has apparently a single annulation extending into the lateral lobe."

Having obtained several nearly entire specimens of this species we are enabled to corroborate the description given by Prof. Hall and to add details of interest.

The position of the elongate eye-lobe and the direction of the facial suture have been referred to in our note on the genus. The great length of the postero-lateral spines of the head is even greater than mentioned by Prof. Hall, as they fully equal and pass beyond the entire length of the thorax and pygidium. The free cheeks are narrow, united (?) in front of the glabella, shorter than the length of the fixed cheek (a character of the genus Anopolenus Salter), and longitudinally striate on the margin, a character that extends around the front and back nearly to the termination of the spines.

The hypostoma is of a peculiar type. The anterior margin extends forward from each antero-lateral angle, meeting at an obtuse angle at the front margin of the doublure, the latter being cut away to permit this extension of the hypostoma to cross it. Back of the line of the doublure the hypostoma is transversely quadrangular in outline and marked very much as in *Centropleura Loveni* Angelin. The only genus known to me that has the anterior margin of the hypostoma rising to an obtuse angle is Cryptonymus, as shown in *C. punctatus* Wahl. (Pal. Scan., Angelin, tab. iv, fig. 6, 1852; also, Quart. Journ. Geol. Soc., vol. vi, pl. xxxii, fig. 1*a*, 1850). In other respects there is little similarity.

Prof. Hall, in speaking of the median axis, says that "there are eleven body rings, including the elongate posterior one; but behind this there are three annulations of the axis, the two anterior of which have somewhat the appearance of free segments, and are likewise marked upon the lateral lobes, while the pygidium below has apparently a single annulation extending into the lateral lobe. In three examples preserving the thorax and pygidium united, we find the two segments between the pygidium and large-extended segment free. They are short, and with but a slight pleural lobe, the extension of the eleventh segment crowding them into the narrow space between it and the pygidium.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's farm, town of Georgia, Vermont.

Genus PTYCHOPARIA Corda.

Ptychoparia Corda, 1847. Prodrom. Mon. böhm. Trilobiten, p. 141. Abh. der k. böhm. Gessell. der Wissenschaften.
= *Conocephalus* Zenker, 1833, not *Conocephalus* Thunberg, 1812.
= *Conocephalites* Barrande, 1852.

I have given, in Bull. U. S. Geol. Survey, No. 10, p. 34, the history of the names Ptychoparia and Conocephalites and my reasons for using Ptychoparia.

PTYCHOPARIA KINGI Meek (sp.)

Plate xxvii, fig. 4, 4*a*.

Conocoryphe (*Conocephalites*) *Kingii* Meek, 1870. Proc. Acad. Nat. Sci. Phila., vol. xxii, p. 63.
Conocoryphe (*Ptychoparia*) *Kingii* Meek, 1873. Sixth Ann. Rep. U. S. Geol. Surv. Terr., p. 487. (Generic reference changed.)
Conocoryphe (*Ptychoparia*) *Kingii* White, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., vol. iv, pt. 1, p. 40, pl. ii, figs. 2*a*–*c*.
Conocoryphe (*Ptychoparia*) *Kingii* Meek, 1877. Geol. Expl. Fortieth Par., vol. iv, pt. 1, p. 20, pl. i, fig. 4.

Original description.—"Entire form ovate and much depressed, with breadth equaling about two-thirds the whole length. Cephalic shield semicircular, or a little wider than long, with the anterior and antero-lateral borders regularly rounded in outline and provided with a narrow, slightly defined marginal rim; posterior margin nearly straight, with the lateral angles terminating in abruptly pointed extremities, so short as scarcely to project as far backward as the posterior margin of the second thoracic segment. Glabella depressed nearly even with the cheeks, about two-thirds as long as the entire head, and between one-third and one-fourth the breadth of the same behind, but narrowing forward to its subtruncated anterior end, and separated from the cheeks on each side and in front by a shallow furrow; occipital furrow moderately well defined, and continued as rather deep broad furrows along the posterior margin of the cheeks out nearly to the points where the facial sutures cut the margin; lateral furrows not clearly defined in the specimens, but apparently consisting of four pairs. Facial sutures directed at first, for a short distance, forward from the inner anterior end of each eye, then curving gracefully outward as they extend forward, until near the anterior margin of the head, where they are a little wider apart than the distance between the eyes, but again curving rather abruptly inward, so as to reach the anterior margin nearly on a line with each eye; posteriorly these sutures extend at first outward, nearly at right angles to the longitudinal axis, from the posterior end of each eye, and then curve gracefully backward so as to intersect the posterior margin between one-fourth and one-third the distance from the lateral angles, inward toward the glabella. Eyes rather depressed, slightly arched outward, and separated from each other by a space somewhat less than half the entire breadth of the head, and placed less than their own length in advance of the posterior margin, and about once and a half their length behind the front margin of the head; visual surfaces narrow, and not showing any lenses under a good magnifier.

"Thorax with its length bearing the proportions to that of the head, of 79 to 52, and to its own breadth, of 79 to 107, being very slightly wider near the middle than in front, and narrowing posteriorly, with gently convex lateral margins, from behind the middle to the pygidium. Axial lobe depressed, narrow, or only about two-thirds the breadth of each lateral lobe at its anterior end, and narrowing regularly with straight sides posteriorly; segments thirteen, nearly or quite straight, and each with a small node or prominence at each end. (In some specimens these nodes seem to be wanting, while in others they do not exist on all of the segments.) Lateral lobes depressed or nearly flat; pleuræ almost transverse or arching slightly backward to near the extremities, which are abruptly pointed; each with a well-defined furrow, which commences small near the anterior inner end and widens and deepens for about half way out, and then narrows and becomes more shallow, so as to die out before reaching the lateral extremities.

"Pygidium subsemicircular, being rounded posteriorly, with a narrow, slightly flattened border, and somewhat rounded anterior lateral extremities; length bearing to that of the thorax the proportions of 30 to 79, and to that of the head of 30 to 52, with a breadth of not quite two-thirds of that of the head; axial lobe equaling more than two-thirds the length, narrow, depressed, and showing more or less distinctly about five segments; lateral lobes much depressed, nearly twice as wide at the anterior end as the middle one, each with about three segments, which curve a little backward and become obsolete before passing upon the narrow, smooth border; segments each provided with a comparatively large longitudinal furrow, corresponding to those on the pleuræ.

"Entire surface apparently smooth, excepting fine radiating striæ on the anterior and lateral portions of the cephalic shield that are scarcely visible without the aid of a magnifier.

"Whole length, 1.60 inch; breadth of thorax, 1.07 inch; breadth of cephalic shield (somewhat flattened by pressure), about 1.12 inch; length of thorax, .70 inch; length of pygidium, .30 inch; breadth of pygidium .60 inch."

The very short genal spines of the head and also the peculiar curvature of the posterior margin between the facial suture and the spine, as shown in Mr. Meek's type specimen, are owing to the breaking away of the outer marginal rim and outer side of the spines with it, and the posterior marginal rim is crushed and bent out of shape and also partly broken away. Twenty entire specimens show the spines and marginal rim as in the figure given by Dr. White and as in the figures on plate xxvii.

Formation and locality.—Middle Cambrian. House Range, Antelope Springs, Utah.

PTYCHOPARIA ADAMSI Billings sp.

Plate xxvi, figs. 1, 1*a–c*.

Conocephalites Adamsi Billings, 1861. Geology of Vermont, vol. ii, p. 950, fig. 355; Pamphlet (1861) republished (1865) in Pal. Foss., vol. i, p. 12, fig. 15. *Idem*, 1863. Geol. Canada, p. 286, fig. 294.

Conocephalites arenosus Billings, 1861. Geology of Vermont, vol. ii, p. 952, fig. 358. *Idem*, 1865. Pal. Foss., vol. i, p. 15, fig. 18; Geol. Canada, p. 286, fig. 297.

Original description.—"Head broad, semicircular, moderately convex; glabella oblong-conical, nearly two-thirds the length of the head, the front obtusely rounded or somewhat straight, the anterior angles narrowly rounded, the sides nearly straight from the anterior angle to the neck furrow, just in advance of which is the widest part. The neck furrow well defined all across; the glabellar furrows indistinct; the dorsal furrow is well defined all round the glabella. The cheeks are moderately tumid; a line drawn across the glabella about the mid length would pass through the eyes. The distance of the eye from the dorsal furrow is equal to the greatest width of the glabella; the eye appears to be very small. The margin in front of the glabella is equal in width to about one-third the whole length of the head; it is bordered by an obtuse, narrow, elevated rim, just within which is a groove which is more deeply impressed on each side than directly in front of the glabella, there being at this place a gently convex elevation, resembling that which occurs in Barrande's species, *C. Sulzeri* and *C. Coronatus*. The ocular ridge is well defined where the surface is preserved, but is rarely visible in the sandstone casts. Most of the specimens are distinctly carinate along the median line of the glabella.

"It is possible that there may be a median tubercle on the neck segment, but none of our specimens have this part sufficiently well preserved to show it.

"The following are the dimensions of a specimen of the average size: Length of head, five lines; length of glabella, three and one-fourth lines; greatest width of glabella, two lines; width of glabella at front, one and one-fourth lines; distance of eye from side of glabella, two lines.

"Dedicated to the late Prof. C. B. Adams, State geologist of Vermont.

"*Formation and locality.*—Highgate, Vermont, in the Potsdam group, about a mile east of the Highgate Springs."

On assembling a large number of specimens of the head of this species from limestone, arenaceous and argillaceous shale, and arenaceous limestone, we find that it is even more variable than as described by Mr. Billings and that it includes the form given by Mr. Billings as *C. arenosus.* On plate xxvi figures of the head are given to show variations.

The frontal limb, between the glabella and margin, varies in breadth and, in the smaller heads, is very narrow; the frontal rim also varies very much in thickness and breadth. In specimens from a purplish-colored limestone, the maceration of the test, prior to mineralization, appears to have gone so far that nearly all the outlines of the glabella, frontal limb, and rim were lost by the compression accompanying the consolidation of the sediment.

In the collections of the Museum of Comparative Zoölogy, Cambridge, Massachusetts, there is a matrix of a nearly entire individual of this species 18^{mm} in length, from Parker's quarry, and the U. S. Geological Survey collection includes the greater part of a specimen 40^{mm} long. From these we obtain a description of the thorax, pygidium, and free cheeks of the head in addition to Mr. Billings's description.

The free cheeks are narrow and terminate posteriorly in sharp spines that reach back even with the fifth segment of the thorax.

Thorax with sixteen segments, narrowing gradually to the tenth segment and then more abruptly to the pygidium; axial lobe about three-fifths the width of one of the pleural lobes; segments narrow, rounded on the axial lobe, and flattened on the pleural lobes; the pleural lobe is flattened about one-half the distance from the axial lobe to its outer margin and then bent downward, and each segment directed slightly backward; pleural groove broad, well defined, and extending nearly to the end of the segment.

Pygidium small; axial lobe short, obconical, and marked by two or more rings; lateral lobes showing the pleural grooves corresponding to the axial rings.

Surface finely granulose under a strong magnifier (Tolles's $\frac{3}{4}$-inch triplet).

Formation and localities.—Middle Cambrian, Georgia Formation. Franklin County. Vermont. East of Highgate Springs the species ranges through the purplish and reddish magnesian limestone and up into the argillaceous shales, a total distance of over 1,500 feet. It occurs at the same relative horizon on the Bullard farm east of Swanton, and also at Parker's quarry in the town of Georgia; also, in the conglomerate lime-stones of Bic Harbor, below Quebec, on the St. Lawrence River, Canada.

PTYCHOPARIA TEUCER Billings.

Plate xxvi, fig. 3.

Conocephalites Teucer Billings, 1861. Geology of Vermont, vol. ii, p. 951, fig. 356; Pamphlet (1861) republished in Pal. Foss., vol. i, p. 13, fig. 16, 1863; Geol. Canada, p. 286, fig. 295.

Original description.—"Head semi-oval; glabella conical, convex, well defined all round by the dorsal furrows, about two-thirds the whole length of the head, widest just in advance of the neck furrow, sides gently convex, front neatly rounded, neck furrow well defined all across; posterior furrows commencing at about one-half the length of the glabella, and running inwards and backwards nearly to the neck furrow and one-third across; median furrows curved backwards, and extending one-fourth across; anterior furrows short; ocular ridges well defined; front margin one-third the whole length of head, with a well-defined groove running across, in front of which there is an elevated marginal rim, which rises with a flat slope upwards and forwards; the groove across the margin is situated at about one-fourth the distance from the front of the glabella to the elevated edge of the rostrum; the cheeks are moderately tumid; the neck segment is well developed, with a small median tubercle scarcely the fourth of a line in height, which in some specimens seems to be absent altogether.

"Thorax of 13 or 14 segments; axis strongly defined, cylindrical; side lobes about one-third wider than the axis.

"The pygidium is very small, being scarcely one-sixth the length of the thorax. The only specimen in which it has been observed attached to the thorax is not sufficiently well preserved to enable me to describe it in detail.

"The following are the measurements of two of the specimens: Length of head, 4⅓ lines; length of glabella, 3 lines; width, just in advance of the neck furrow, 2⅓ lines, and at one-third the length from front margin 2 lines.

"In a specimen consisting of the thorax and pygidium the whole length is 6 lines, of which the pygidium occupies apparently a little less than 1 line. Width at first segment, 5½ lines; width of axis at same place, 1½ lines; width at anterior margin of pygidium, about 3 lines.

"The position of the eye is not shown in any specimen that I have seen, but, from the width of the portions of the fixed cheeks which remain, it must be distant from the dorsal furrows nearly the width of the glabella.

"This species appears to be closely allied to the one above cited from Shumard's paper, so far as the characters of the glabella are concerned. As, however, the proportions are a little different, I shall dispose of it as above until I can have an opportunity of submitting a specimen to Dr. Shumard.

"*Locality and formation.*—One and one-half miles east of Swanton, in Vermont, in the slates of the Potsdam group."

Mr. Billings describes an entire specimen, but does not figure it, and we have been unable to obtain any more than the head exclusive of the free cheeks.

The most marked difference between the head and that of *P. Adamsi* is in the form of the frontal limb.

A comparison with specimens of *P. Billingsi*, from Texas, shows it to be a distinct species.

Formation and locality.—Middle Cambrian, Georgia Formation. About 1½ miles east-northeast of Highgate Springs, Vermont; also, in the conglomerate limestones at Bic Harbor below Quebec, on the St. Lawrence River, Canada.

PTYCHOPARIA VULCANUS Billings.

Plate xxvi, figs. 4, 4*a*.

Conocephalites Vulcanus Billings, 1861. Geology of Vermont, vol. ii, p. 952, fig. 357; Pamphlet 1861, republished (1865) in Pal. Foss., vol. i, p. 14, fig. 17; Geol. Canada, 1863, p. 286, fig. 296.

Original description.—"Head broad, moderately convex; glabella obtusely conical, with the neck segment triangular and extended backwards in the middle; neck furrow not extending across, being interrupted by a strong carina which runs along the median line; dorsal furrow all round, but not sharply defined. Front margin about one-third the length of whole head, with a projecting rim, and a transverse groove situated two-thirds the distance from the front of glabella. Cheeks moderately convex; ocular ridge well defined; a line drawn across the head a little in advance of the mid-length of the glabella would pass through the eyes; the latter distant from the glabella at least half the whole length of the head. No indications of glabellar furrows visible.

"Length of head, four and one-third lines; of glabella, including the backward projecting angle of the neck segment, three lines; width of glabella just in advance of neck furrow, two and one-third lines; distance of eye from glabella, two and one-fourth lines.

"This species differs from *C. Adamsi* in the character of neck furrows and in the greater proportional width of the glabella.

"It was found along with *C. Adamsi* in the same beds."

This species varies in the shape of the glabella, occipital segment, and frontal limb so much that I am inclined to consider it a little more than a variety of *P. Adamsi* or *P. Teucer*, as it is intermediate to them in many of its characters. An illustration is given of an extreme form and also of one that approaches more nearly to that of *P. Adamsi.*

It is associated with *P. Adamsi* at all the localities where it has been found.

Formation and localities.—Middle Cambrian, Georgia Formation. Franklin County, Vermont, Parker's quarry, and also one mile east of Highgate Springs.

PTYCHOPARIA MISER Billings.

Plate xxvii, fig. 2.

Conocephalites miser Billings, 1861. Geology of Vermont, vol. ii, p. 950, fig. 354; also in pamphlet. *Idem*, 1863. Geology of Canada, p. 286, fig. 293. *Idem*, 1865. Pal. Foss., vol. i, p. 12, fig. 14.

Original description.—"Glabella elongate, conical, very convex, most elevated at about the mid-length, slightly narrowed at the neck segment, widest in the middle, narrowly rounded in front, well defined all round by the dorsal furrows. Neck segment strongly convex and bearing a short broad-based spine directed upwards and backwards. Neck furrow extending all across; the posterior glabellar furrow well defined across, forming an obtuse angle backward in the median line; median glabellar furrow also running across, but not so strongly defined as the posterior; anterior furrows extending one-third across.

"Length of glabella, two lines; width in the middle, about one-half the length.

"There is no described species to which this one bears any close relation, on account of the peculiar character of the posterior and median furrows running quite across the glabella."

In looking over the collection of the Canadian Geological Survey with Prof. J. F. Whiteaves, we found a more perfect example of the head than that figured by Mr. Billings, and I was kindly permitted to have a figure made of it. The frontal limb, fixed cheeks, palpebral lobes, and postero-lateral limbs are shown in addition to the parts described by Mr. Billings.

Formation and locality.—Middle Cambrian. In limestone, associated with fossils characteristic of the Georgia Formation of Vermont, L'Anse au Loup, on the north side of the Straits of Belle Isle.

PTYCHOPARIA QUADRANS H. & W.

Plate xxix, figs. 4, 4*a*, *b*.

Crepicephalus ? (*Loganellus*) *quadrans* Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 238, pl. ii, figs. 11–13.

Compare *P. Adamsi* and *P. Kingi.*

Original description.—"Form of entire body unknown. Glabella and fixed cheeks together broadly quadrangular, about four-fifths as high as wide and quite uniform in many individuals, very depressed-convex or quite flattened, as occurring on the surface of the shale in which they are imbedded; glabella distinctly conical, moderately tapering above the occipital furrow, and broadly rounded in front; marked by three pairs of distinct transverse furrows, which are directed obliquely backward from their outer ends; the posterior pair almost or quite meeting in the middle, the others shorter and situated at almost equal distances from each other. Occipital furrow well marked, proportionally wide and shallow; occipital ring narrow, not well defined.

"Fixed cheeks very broad, nearly two-thirds as wide as the glabella, depressed-convex; frontal limb short, the broader and inner part of nearly the same width; sides of the limb in front, wide, and slightly rounded at the antero-lateral angles; posterior limb wide at its junction with the glabella, and rapidly narrowing outward, being about once and a half as long as its greatest width; ocular ridges slender, but very distinct, rising from the anterior angle of the eye and uniting with the glabella near the anterior furrow, forming a slightly curved line parallel with the marginal furrow of the head.

"Facial sutures directed inward from the anterior margin of the head to the eye-lobe, behind which they are directed outward and backward to the posterior margin of the head, at an angle of about forty degrees to the occipital line.

"A form of movable cheek found associated in considerable numbers with the glabellas, and corresponding in size and character, is narrowly triangular, the posterior extremity terminating in a short, blunt spine, slightly curved; inner angle strongly notched for the reception of the eye-lobe, and the outer margin bordered by a thickened, rounded rim, which gradually increases in width to the base of the spine. The facial suture corresponds to the margin of the fixed cheek above described, and, on the under side, the anterior border is prolonged in the form of an acute process, to extend along the anterior border of the frontal limb.

"The pygidium associated with the above specimens is minute, transversely subelliptical in form, most strongly rounded on the front border, with a wide axis terminating obtusely a little within the posterior margin. The axis is marked by five rings, exclusive of the terminal ones. Lateral lobes convex, marked by three or four divided ribs, exclusive of the anterior single one.

"Surface of the head and cheeks marked by fine anastomosing lines, radiating from the eye and front of the glabella."

This species, as far as we know its structure, is closely allied to *Ptychoparia Kingi*, and, with the latter species, to *P. Adamsi.* They are the representatives of the same specific type in the distinct localities at which they occur.

P. quadrata is associated with *Olenoides Wahsatchensis* in a dark, shaly argillite.

The figure of the head on pl. ii, fig. 11, Geol. Expl. Fortieth Par., vol. iv, is that of an unusually elongated specimen, and not the form that is most abundant. We give one that is the average form of a number of heads found at the type locality.

Formation and localities.—Middle Cambrian. Above Call's Fort, north of Box Elder Cañon, and one mile below Argenta, in Big Cottonwood Cañon, Wasatch Mountains, Utah.

PTYCHOPARIA HOUSENSIS, n. sp.

Plate xxv, fig. 5.

Head small, transversely quadrilateral exclusive of the free cheeks; moderately convex. Glabella rather small, of almost uniform width from the posterior margin to the rounded front; furrows shown only by a posterior pair; occipital ring strong and bearing a short small spine that extends obliquely upward and backward; occipital furrow of moderate depth and continued out as a strong groove on the lateral limbs; dorsal furrows broad and well defined. Fixed cheeks wider than the glabella; palpebral lobes small; ocular ridges strongly defined; frontal limb concave, of medium width, and rising to a strong frontal rim; postero-lateral limbs short. Surface finely granulose.

Free cheeks, thorax, and pygidium unknown.

This peculiar little head is associated with *Ptychoparia Kingi* and *Asaphiscus Wheeleri*, and, while we have over one hundred perfect specimens of these two species from the same bed, but one fragment of *P. Housensis* has been found. This is so strongly characterized by its form and occipital spine that I do not hesitate to give it a specific name.

Specific name derived from the House Range.

Formation and locality.—Middle Cambrian. House Range, Antelope Springs, Utah.

PTYCHOPARIA PIOCHENSIS, n. sp.

Plate xxvi, figs. 2, 2*a*, *b*; pl. xxviii, figs. 1, 1*a*–*e*.

General form ovate, moderately convex, usually much depressed by being flattened in the shaly matrix.

Head transverse, semicircular; frontal margin comparatively narrow in young individuals, becoming broader and more flattened with the increase in size of the animal; postero-lateral angles prolonged into slender spines. Glabella of medium size, truncato-conical, and marked with three pairs of short glabellar furrows that increase in size and also in obliquity to the central axis on the larger heads; occipital groove shallow and rounded downward from the base of the glabella and upward to the moderately strong occipital ring; a small point or node occurs at the center of the latter. Fixed cheeks of medium width; they merge in front into [illegible] frontal limb and posteriorly into the elongate, narrow, postero-lateral limbs; palpebral lobes small; ocular ridges well defined and terminating nearly at the front of the glabella; frontal limb comparatively narrow in the young and broader in the older and larger specimens.

Thorax with 19 segments in two specimens 30mm and 40mm long, respectively; another specimen, 18mm long, shows 17 segments; the segments are nearly transverse, except at the geniculation on the pleural lobes, where the falcate extremities bend slightly backward; axial lobe moderately convex; pleural lobes flattened half-way out and then curved downward to their margin; pleural groove of medium width and continued well out towards the extremity of the segment.

Pygidium small, semicircular; axial lobe with 3 or 4 segments; lateral lobes small and marked by furrows indicating about 3 united segments.

Surface apparently smooth except on the frontal limb and free cheeks, where fine, irregular striæ radiate towards the margin.

The large number of segments in the thorax, 19, is a marked peculiarity of this species, the usual number of segments in the genus being from 13 to 15. The expansion of the frontal limb with the increase in size is also very suggestive, as, in the adult, we have the broad, companulate limb, and, in the young, the narrow limb with an elevated outer margin; a variation that would be given as specific if the intermediate forms were absent. The small pygidium resembles that of *Ptychoparia Emmrichi* (see Syst. Sil. Bohême, vol. i, pl. xi, fig. 4), except that it is proportionally smaller.

Formation and locality.—Middle Cambrian. In an argillaceous shale, at the Chisholm Mine, on the southwest slope of the Ely Mountains; also, on the western slope of the Highland Range, 8 miles north of Bennet's Spring, Nevada.

PTYCHOPARIA sp. ?

Associated with *Olenellus Gilberti* in a gray, granular limestone, at Pioche, there is a species of Ptychoparia that is closely allied in the head parts to *P. Adamsi*. The material is too imperfect to determine satisfactorily, at present, its specific relations.

PTYCHOPARIA ? PROSPECTENSIS Walcott.

Plate xxvii, fig. 5.

Ptychoparia ? Prospectensis Walcott, 1884. Monographs U. S. Geol. Survey, vol. viii, p. 46, pl. ix, fig. 20.

The general outline of the head is moderately convex, semicircular, the width being about twice the length.

The glabella is subconical, truncate in front, and marked by three pairs of short, slightly impressed, glabellar furrows; occipital ring distinctly defined by a narrow, lightly impressed, occipital furrow; fixed cheeks broad, of equal elevation with the glabella, and extending beyond it anteriorly, the space between them on the broad frontal limb being occupied by a small swelling or boss that, but for the slight transverse dorsal furrow between it and the glabella, might be mistaken for a continuation of the latter; the eye lobes are comparatively large for a species of this character and occupy a prominent position on the outer margin of the cheeks, a distinct ocular ridge crossing the latter from the anterior margin of the eyes to the dorsal furrow on a line with the front of the glabella; the lateral limbs are narrow, rather short, and slope rapidly downward back of the eye-lobes; frontal limb broad at the center, narrowing in front of the fixed cheeks, and bordered anteriorly by a not very distinctly defined rounded margin. The facial suture curves a little inward in front of the eye and appears to terminate on the front line somewhat in advance of a line passing through the center of the tubercle in front of the glabella; behind the eye it extends obliquely outward and backward to the posterior margin of the head, outlining an elongate triangular postero-lateral limb.

Under a strong magnifying power the surface is seen to be finely granulose (see p. 32).

Free cheeks, thorax, and pygidium unknown.

Its associated species are mentioned in the introductory remarks of this bulletin.

Formation and locality.—Middle Cambrian. Mountain shale band of the Prospect Mountain section, on the east slope of Prospect Peak, Eureka District, Nevada.

PTYCHOPARIA TRILINEATA Emmons (sp.).

Plate xxvii, fig. 1, 1*a–c*.

Atops trilineatus Emmons, 1844. Taconic system, p. 20, fig. 1, pl. ii, fig. 3. *Idem*, 1847. Agrl. Rep. N. Y., vol. i, p. 64, fig. 8; pl. xiv, fig. 3. *Idem*, 1849. Proc. Amer. Assoc. Adv. Sci., vol. i, pp. 16, 17. *Idem*, 1855. Amer. Geol., vol. i, pt. 2, p. 115, pl. i, fig. 16.

Atops trilineatus Haldeman, 1848. Amer. Jour. Sci., 2d ser., vol. v, p. 107.

Atops trilineatus Barrande, 1861. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 269, pl. v, fig. 1.

Calymene Beckii Hall, 1847. Pal. N. Y., vol. i, p. 252, pl. lxvii, figs. 4*a–e*. *Idem*, 1848. Amer. Jour. Sci., 2d ser., vol. v, p. 322.

Calymene Beckii Fitch, 1849. Trans. Agrl. Soc. N. Y., vol. ix, p. 865.

Calymene Beckii Walcott, 1879. Pamphlet in advance of vol. x, Trans. Albany Inst., p. 23.

Atops punctatus Emmons, 1859. Manual of Geology, p. 88, fig. 71.

Atops punctatus Barrande, 1861. Bull. Soc. Géol. de France, 2e sér., t. xviii, p. 271, pl. v, fig. 3.

Conocephalus (Atops) trilineatus Ford, 1871. Amer. Jour. Sci., 3d ser., vol. ii, p. 33.

Conocephalites trilineatus Ford, 1873. Amer. Jour. Sci., 3d ser., vol. vi, p. 135.

Conocephalites (Atops) trilineatus Ford, 1875. Amer. Jour. Sci., 3d ser., vol. ix, p. 205.

Triarthrus trilineatus Miller, 1877. Cat. Amer. Pal. Foss., p. 223.

Conocoryphe Ford, 1880. Amer. Jour. Sci., 3d ser., vol. xix, p. 152.

This trilobite has an interesting history that connects it with the Taconic controversy. First characterized by Dr. Emmons as typical of the Taconic system, it was considered by Prof. Hall the same as the *Triarthrus Becki* of the Utica slate, and not of importance in establishing a different geologic horizon for the Taconic slates. It was not until Mr. Ford, in 1871, published a list of the fossils known to him from the conglomerate limestones east of Troy, N. Y., that the question was satisfactorily settled, a fact overlooked by the writer in preparing a list of the synonyms of *Triarthrus Becki* in 1879 (Trans. Albany Inst., vol. x, p. 23).

The original specimens figured by Dr. Emmons were fragmentary and very much compressed, and the figures of the head and three segments of the thorax of the best specimens are not so good as the original specimen that is now preserved in the collection of the American Museum of Natural History, New York, a figure of which is given on plate xxvii, fig. 1. Subsequently (Amer. Geol., p. 115, 1855) Dr. Emmons described a much more perfect specimen, as follows:

"Crust granulated, cephalic shield semicircular, with its anterior and lateral edges turned upwards; posterior angles rounded, facial suture beginning at the outer angle of the cephalic shield and runs nearly parallel with the anterior margin to the middle lobe, when it turns at a right angle and runs parallel with that lobe; eyes undistinguishable, body composed of seventeen or eighteen rings, narrowing very gradually to the caudal extremity; pygidium a flat expansion of the crust, and is provided with a single ring; axis narrower than the lateral lobes; rings seventeen, each of which is separated by a groove about as wide as the rings. Axis armed by a row of short spines; lateral lobes provided with a row of tubercles or prominences along the median line; margins of the rib groove run parallel as far as the tubercle, when they diverge; tubercles become obsolete towards the tail; caudal shield very small and provided with one or at most two rings."

The figure which we reproduce on plate xxvii (fig. 1*c*) is that of the specimen described; it is crushed, and if the same liberty was taken in making the drawing that was used in that of the first figure we cannot place much reliance on the details. The whereabouts of the specimen is unknown to me.

Dr. Emmons afterwards considered this specimen as belonging to a distinct species, *A. punctatus;* but, from the fact that the original does not preserve the outer shell and that from the parts preserved we cannot judge of its specific distinction, I have considered them as belonging to one species.

The first type specimen shows an ocular ridge and traces of the direction of the facial sutures the same as in typical species of the genus Ptychoparia.

The generic name Atops preceded that of Ptychoparia, but it was not until years after Ptychoparia had been thoroughly described, illustrated, and published that Dr. Emmons so defined *Atops trilineatus* that even the specific characters could be determined. The simple proposal of a name without figures or description by which congeneric forms could be included within it is not sufficient to warrant our use of the name Atops in place of Ptychoparia.

Formation and locality.—Middle Cambrian. Reynold's Inn, seven miles north of Union Village, Washington County, New York; in the conglomerate limestones on the ridge east of the city of Troy, New York; also, in conglomerate limestones of Bic Harbor, below Quebec, on the St. Lawrence River, Canada.

PTYCHOPARIA SUBCORONATA H. & W.

Plate xxviii, fig. 4.

Conocephalites subcoronatus Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 237, pl. ii, fig. 1.

Original description.—"Glabella short, conical, with straight lateral margins, regularly converging from the base upward to the rather squarely truncated summit; height above the occipital furrow scarcely exceeding the breadth of the base, and the width at the summit equal to about two-thirds of the height; marked by three pairs of very oblique, subequally distant, and moderately distinct transverse furrows. Occipital furrow narrow and well marked; ring distinct, widest and somewhat pointed on the center of the posterior margin.

"Fixed cheeks wide, separated from the glabella by distinct dorsal furrows, prominent and rounded between the glabella and eye-lobe, almost equaling the convexity of the glabella; ocular ridges slender and curved. Frontal limb wide and concave, destitute of a thickened marginal rim, as long as the glabella, and obscurely trilobed from an extension of the dorsal furrows, forming a convex, boss-like area in front of the glabella, which is divided transversely by a double depressed line, or narrow fillet, midway of the limb and parallel with the anterior margin of the head. Eye-lobes about half as long as the glabella, obliquely situated, and separated from the fixed cheek by a deeply-depressed ocular sinus.

"Facial suture cutting the anterior border on a line with the front angle of the eye, which it reaches by a broad convex curvature, giving rounded lateral margins to the frontal limb; posterior to the eye it is directed outward, the actual course not determined. Posterior lateral limbs not seen. Surface of the crust in front of the glabella strongly striated.

"The species is only known by the glabella and fixed cheeks. The specimens are all minute, but readily recognized by the peculiar formed boss in front of the glabella."

This species is associated with *Olenoides quadriceps* in the same pieces of rock. Its nearest allies are *P. Prospectensis* and *P.? Linnarssoni* (Monographs U. S. Geol. Survey, vol. viii, pp. 46–48). They all have a cylindro-conical glabella, with a rounded boss on the frontal limb; rather wide fixed cheeks, and medium-sized eye lobes. Specifically *P. subcoronata* differs from the other two species very decidedly.

Formation and locality.—Middle Cambrian. Ute Peak, Wasatch Range, Utah.

This species was originally referred to the Quebec Group, but, as mentioned under the description of *Olenoides quadriceps*, the reference is now known to be incorrect.

Genus CREPICEPHALUS Owen.

Crepicephalus Owen, 1852. Rep. Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 576.

Original description.—"Generic character. Some rich Trilobite slabs, occupying the position of the third Trilobite-bed at the Mountain Island section, contain numerous fragments of a Trilobite, a portion of the cephalic shield of which is seen on the medal-ruled slab, fig. 16 of Tab. I. A., on the left corner, as well as by figs. 10 and 18 of the same plate. These, as far as preserved, approach somewhat in form to the genera *Solenosema*, *Micropyge*, and *Endogramma;* but if the caudal shields, fig. 8 of Tab. I. and fig. 16 of Tab. I. A., correspond, which seems improbable,[1] as they are abundantly disseminated in the same bed and are mineralized in the same manner into a brown, ferruginous crust, contrasting strongly against the gray gritstone, then this Trilobite of Mountain Island must constitute a genus distinct from either of these, and for which the name Crepicephalus is proposed.

"The rather flat, slipper shaped glabella is tapering and slightly acuminated anteriorly, with a faint ridge in the median line; two small and very superficial depressions, and a posterior faint furrow, very partially divide the glabella. The facial sutures run nearly parallel to the margin of the glabella, and join a thickened, cord-like, anterior narrow border, inclosing a convex area, narrower in front than at the sides. Oblique plications can sometimes be traced on the cheek-plate, in advance of the eye, converging towards the apex of the glabella.

"If the associated pygidiums, fig. 8 of Tab. I. and fig. 16 of Tab. I. A, belong to Trilobites of this species, they are relatively larger than those of any of the above genera. The axal lobe has four segments; side lobes bounded by a slightly concave border, which widens posteriorly, and of which the confines are almost rectangular, with rounded corners."

From a careful reading of the author's description of this proposed genus and a study of all the figures referred to it and also of a series of specimens from the type locality, there is but little doubt that *P.* (*Crepicephalus*) *Iowensis* is the species to be taken as the type of the genus.

[1] This is undoubtedly a typographical error, as the sentence is rendered meaningless unless the word *probable* is used.—C. D. W.

On pp. 34–36 of Bulletin 10, U. S. Geological Survey, I have spoken of the relations of the genera Ptychoparia, Crepicephalus, &c., stating that Crepicephalus might be used as a subgenus on account of its peculiar pygidium. The projecting postero-lateral spines of the pygidium are also present in other genera of trilobites, but not just in the same way. The nearest I know of is the pygidium of *Ceratopyge forficula* Sars (Die sil. Etagen 2 und 3, &c.; W. C. Brögger, 1882, pl. iii, figs. 19–22), where the spines are the extension beyond the border of the second anchylosed segment of the central axis. The head of this species is entirely distinct from that of *P.* (*C.*) *Iowensis*. We now have, in the Geological Survey collections, three well-marked species of the group; one from the Potsdam horizon is represented by entire specimens, some of which have a length of 15^{cm} ($5\frac{7}{8}$ inches), exclusive of the two postero-lateral spines of the pygidium, which give an entire length of 20^{cm}. This is the largest species of the Conocephalidæ that is known to me. It will be illustrated in the study of the Upper Cambrian faunas.

CREPICEPHALUS LILIANA n. sp.

Plate xxviii, figs. 3, 3*a-c*.

Head semicircular in outline and terminating in round, sharp, postero-lateral spines of moderate length. Glabella truncato conical, tapering moderately to the front, height and width at the occipital furrow about equal; marked by three pairs of furrows; the two posterior extend obliquely inward and backward and the anterior pairs are nearly transverse in direction; the anterior pair is often very faintly indicated, and on the glabellas of young individuals, 2^{mm} or 3^{mm} in length, the furrows show only as faint depressions on the smooth surface; occipital furrows broad and well defined; occipital segment strong and moderately elevated; dorsal furrows distinct.

Fixed cheeks broad as the glabella opposite the eyes; posteriorly they broaden out in the short postero-lateral limbs, and anteriorly merge into the frontal limb, which is of moderate width, slightly convex, and bordered anteriorly by a flattened margin about as broad as the distance from the front of the glabella to the slight but distinct depressions between the frontal limb and the margin; postero-lateral limbs grooved near the posterior margin by a distinct furrow. Eyes lunate, about one-third as long as the length of the glabella; a strong ocular ridge extends from the anterior end of the narrow palpebral lobe with a slightly forward direction, touching the dorsal furrow nearly, but not quite, opposite the antero-lateral angle of the glabella. Facial sutures cut the anterior margin on a line with the sides of the glabella, and extend obliquely inward and outward across the margin and then curve inward and extend to the eye; curving around the palpebral lobe, they extend obliquely outward with a slightly sigmoidal course to the posterior margin. The associated free cheek is irregularly triangular; marginal border strong and produced behind into a medium-sized, sharp spine; central area slightly convex, and marked by striæ that radiate from the base of the eye towards the margin; anteriorly the border narrows to a slender point.

Thorax unknown.

Pygidium subquadrilateral in outline, with strong, slightly-diverging spines extending back from the postero-lateral angles; sides nearly straight, slightly converging posteriorly to the base of the spines; posterior margin a little concave between the spines; axial lobe prominent, convex, and reaching five-sixths of the distance between the front and back margins; the sides converging very little towards the obtusely-rounded posterior end; divided by fine transverse furrows into five segments and an obtuse terminal point; the pleural lobes are grooved by the extension of the grooves crossing the axis; the terminal spines appear to arise from the extension of the anterior segment of the pygidium. There is considerable variation in the strength and direction of the postero-lateral spines, but I find this to be true of the corresponding spines on *Crepicephalus Iowensis*.

Surface of head and pygidium with papillæ of different size scattered over it, sometimes so thickly as to give a granulose appearance to it.

This and associated forms are the only ones we know of this type in the Middle Cambrian. The type is found in the Potsdam horizon of Nevada, Wisconsin, and Alabama, and will be fully described in the review of the Potsdam or Upper Cambrian fauna.

Formation and localities.—Middle Cambrian. In limestone associated with *Olenellus Gilberti*, near Pioche, and also eleven miles north of Bennet's Spring, on the west side of the Highland Range, Nevada.

CREPICEPHALUS AUGUSTA n. sp.

Plate xxviii, figs. 2, 2a, b.

Glabella and fixed cheeks sub-quadrilateral in outline exclusive of the postero-lateral limbs; glabella truncato-conical, sides tapering moderately to the front, height and width at the occipital furrow about equal; marked by four pairs of glabellar furrows; the two posterior pairs extend obliquely inward and backward, the third pair being opposite the anterior end of the palpebral lobe and transverse to the axis of the glabella; the fourth pair are very minute and resemble elongate pits opposite the terminations of the ocular ridges; occipital furrow well defined; occipital segment strong, thickened at the center, and showing a small central node or point near the back margin; dorsal furrows distinct.

Fixed cheeks broad, convex; posteriorly they broaden out into the short postero-lateral limbs, and anteriorly merge into the frontal lobe, which is narrow in front of the glabella, expanding a little laterally; frontal margin slightly convex, and broadest in front of the glabella, narrowing towards the facial sutures, separated from the frontal lobe by a narrow groove that arches slightly forward on each side of the center; in young individuals this groove is nearly obsolete, and the frontal limb appears broader in proportion to the width of the margin. Postero-lateral limbs very short in the small heads and of medium length in the larger; a well-defined groove occurs just within the posterior margin. Palpebral lobes of medium length; ocular ridge narrow, strong on the adult and less distinct on the small heads; starting a little back of the antero-lateral angles of the glabella, they cross the cheek, trending obliquely backward to the anterior ends of the palpebral lobes. Facial sutures cut the anterior margin on a line with the sides of the glabella, and extend obliquely outward and across the broad margin, curving inward as they cross the frontal limb and extending to the eyes, around which they curve on the margin of the palpebral lobe and then extend obliquely outward and backward, with a slightly sigmoidal curve, to the posterior margin. Free cheek unknown.

Thorax unknown.

Pygidium with a short strong axis crossed by three furrows; pleural lobes flattened and marked by the extension of the axial furrows; posteriorly the lobes extend into points, leaving an arched posterior border between the two points of the pygidium.

Surface of head and pygidium papillose; the papillæ are scattered and vary in size; on the smaller heads they are often not present.

This species is distinguished from the preceding, *C. Liliana*, by the elongate form of the head, the more rounded frontal margin, and the character of the associated pygidium; the latter has a short axis, a broader space back of the axis, and the postero-lateral angles terminating in points instead of long spines. The two species are closely related, but we have a large number of specimens of the head of each, and the differences hold good in distinct localities and in different sized heads down to those 3^{mm} in length. The small heads of *C. Augusta* are quite smooth and the groove between the frontal limb and margin is nearly obsolete.

Formation and localities.—Middle Cambrian. Very abundant in limestones of the Olenellus horizon, both in the vicinity of Pioche, and also eleven miles north of Bennet's Spring, Highland Range, Nevada.

Genus ANOMOCARE Angelin.

Anomocare Angelin, 1852. Pal. Scand., p. 24.

ANOMOCARE ? PARVUM Walcott.

Plate xxv, fig. 1.

Anomocare ? parvum Walcott, 1885. Monographs, U. S. Geol. Survey, vol. viii, p. 59, pl. ix, fig. 17.

This is the same species described in Monographs U. S. Geological Survey, vol. viii. No new material has been obtained since the discovery of the original specimen in 1880.

Formation and locality.—Middle Cambrian. In a limestone, associated with *Olenellus Gilberti*, beneath the arenaceous shale carrying *Olenellus Gilberti* and *O. Iddingsi*, West slope of Prospect Mountain, Eureka District, Nevada.

Genus ORYCTOCEPHALUS n. gen.

(ὀρυκτός, furrowed, and κεφαλή, head.)

Glabella oblong, transversely lobed; eye central, with a narrow ocular ridge connecting it with the axial furrow about the glabella; facial suture marginal in front and cutting the posterior margin within the postero-lateral angles; free cheeks spinous.

Thorax unknown.

Pygidium with segmented axis and pleural lobes; margin spinous.

This genus is founded on numerous specimens of the head and pygidium of a small trilobite that, in its generic and family relations, approaches Parabolina of the family Olenidæ. The combination of characters shown in the head and pygidium serve to distinguish it from any generic form known to me.

Type *Oryctocephalus primus.*

ORYCTOCEPHALUS PRIMUS n. sp.

Plate xxix, figs. 3, 3*a*.

Entire head as restored by the union of the free cheeks to the central portions of the head, transverse subsemicircular. Glabella elongate, quadrilateral, sides parallel, front broadly rounded and, in some specimens, showing a slight indentation midway; surface marked by four transverse furrows that terminate in little pits within the margin of the glabella; a shallow depression unites the pits on each side within the margin, and there is on some glabellas a very shallow depression running obliquely backward from each pit to the axial furrow; the transverse furrows uniting the pits are strong and arch a little backward at the center; anteriorly a shallow pit occurs a little back of the antero-lateral angles of the glabella that opens out into the axial furrows; the occipital furrow is represented by the posterior pair of pits and connecting furrow, and the strong occipital segment is united to the glabella at each end within the axial furrows; axial furrows strongly defined.

Fixed cheeks nearly as broad as the glabella; they narrow slightly in front and broaden out posteriorly into the short postero-lateral limbs; frontal limb practically obsolete; a narrow raised margin borders the front of the head; palpebral lobe narrow and with a deep groove between it and the fixed cheek; a narrow ocular ridge crosses the fixed cheek from the palpebral lobe to the axial groove opposite the small anterior depressions on the side of the glabella. Free cheeks elongate, convex, bordered by a narrow rounded rim that extends backward as a short spine; visual surface of eye broken away.

Thorax unknown.

Associated pygidium with a strong axial lobe and divided into five rings and into a terminal elongate ring by five transverse furrows; pleural lobes strongly grooved by four anchylosed pleural segments that terminate in strong, elongate points; a fifth segment terminates in a point on each side of the posterior end of the axial lobe.

Surface of the head and pygidium apparently slightly granulose.

This trilobite is so distinct in its character that, beyond referring the genus to the Olenidæ, there are few comparisons to make save those hinted at under the generic description.

Formation and locality.—Middle Cambrian. In limestone just above the quartzite, east of Pioche, Nevada.

Genus PROTYPUS n. gen.

Type *Protypus Hitchcocki* Whitfield.

The only entire example of an individual of this genus is the type of the typical species, and, until more is known of other species referred to it, the description of the species gives the generic characters.

PROTYPUS HITCHCOCKI Whitfield (sp.)

Plate xxxi, fig. 4.

Angelina Hitchcocki Whitfield, 1884. Bull. Amer. Mus. Nat. Hist., vol. i, 148, pl. xiv, fig. 13.

Original description.—"Body ovate in outline, largest across the base of the head and gradually narrowing behind; distinctly trilobed longitudinally.

"Head broad, semicircular in outline, being about twice as wide across the base as the extreme length from the front margin to the posterior side of the occipital ring. Glabella proportionally large, with parallel sides and rounded front. Surface convex and apparently destitute of any glabellar furrows. Frontal limb narrow in front of the glabella and bordered by a narrow rounded rim. Fixed cheeks proportionally broad, crossed in front of the eyes by a distinct ocular ridge, which is curved and runs nearly parallel to the margin of the head. Lateral limbs large, triangular, and extending nearly to the origin of the cheek spines. Eyes large, reniform, and the palpebral lobes flattened. Occipital ring narrow and divided from the glabella and fixed cheeks by a narrow groove. Movable cheeks elongate-triangular, curved on the outer margin, moderately convex over the central area, and projected backward at the postero-lateral angles in short spines. Facial suture passing a very little outward in its course from the eye to the anterior margin, which it cuts nearly at right angles to the border; behind the eye it passes obliquely outward and backward with a slight curvature to just within the cheek spine, forming a very broadly triangular lateral limb.

"Thorax nearly once and a half as long as the head, consisting of twelve segments, and nearly twice as wide at the anterior as at the posterior end; strongly trilobed, the axial lobe forming one-third of the width anteriorly, but rapidly tapering backward; at the twelfth segment its width does not exceed one-fourth of the whole. Axial lobe convex, the segments well marked, narrow and rounded, separated by broad grooves; pleura straight, direct and flattened for nearly two-thirds of their length, from which point they are rapidly narrowed to a point, which is not recurved, but which is a little back of the central line of the rib. Surface of the pleura broadly channeled, the furrow occupying nearly the entire width of the rib and extending to the extremity.

"Pygidium small, semi-elliptical, and transverse, about four times as wide as long, and marked by three furrows, both on the very small axis and on the lateral areas. Axis terminating within the posterior margin of the plate.

"Surface of the test smooth.

"The generic relations of this trilobite are not exactly those given by its author to the genus *Angelina*, but they are more nearly like them than of any other described. The general form and proportions are very similar, as is also the general appearance; but in the head parts it differs principally in the possesion of very distinct glabellar furrows, which is in direct opposition to the generic diagnosis, and the eyes are larger than those of the typical species. In some lights the specimen figured seems as if it had possessed two pairs of glabellar furrows,[1] but they are so very unsatisfactorily defined that I have chosen rather to consider them as absent. The great difference, however, is the nature of the furrows of the pleura and the pointed extremities of these parts. In the *A. Sedgwicki* the furrow is narrow at each end and broadest and angular at the geniculation, which is near the middle of the length, while in this one the furrow is broad at the inner end of the pleura, and retains its breadth and depth for the entire length, only narrowing as the extremities of the ribs are narrowed, while the extremities of the ribs cannot be fairly said to be bent backward to any degree. These points of difference, although considerable, I have not deemed of sufficient importance to constitute a distinct genus, rather considering that the typical species was followed too closely in the original generic description."

After reviewing the character of the genus *Angelina* and those of the species under consideration, I am led to differ with Prof. Whitfield and to consider the differences of generic importance.

Briefly enumerated, they are: The presence of strong ocular ridges,

[1] The author probably meant *ocular ridges*.

the difference in the type of the pleural lobes of the thoracic segments, and the pygidium of Angelina, which has a spinose margin.

In a second species found at Parker's quarry, *P. parvulus*, very faint glabellar furrows are shown in a natural mold of the glabella.

The only specimen yet known to me of *P. Hitchcocki* is the one described by Prof. Whitfield, and now in the American Museum of Natural History, New York.

Formation and locality.—Middle Cambrian, Georgia Formation. Parker's quarry, town of Georgia, Franklin County, Vermont.

PROTYPUS SENECTUS Billings.

Plate xxxi, figs. 2, 2*a–c*.

Bathyurus senectus Billings, 1861. Geology of Vermont, vol. ii, p. 953, figs. 359, 360. Pamphlet (1861) republished (1865) in Pal. Foss., vol. i, p. 16, 1863. Geol. Canada, p. 286, figs. 298 *a*, *b*.

Compare *Bathyurus parvulus* Billings, 1861, Geol. Vermont, vol. ii, p. 953.

Original description.—"Glabella subcylindrical, clavate, strongly convex, one-fourth wider at the front margin than at the neck segment, sides nearly straight, front obtusely rounded and presenting a strong convex elevation, neck furrow extending all across, three pairs of glabellar furrows represented by small but distinct and obtuse indentations in the sides. Fixed cheeks, rather strongly convex. Eyes of moderate size, semicircular; a line drawn across the head at about one-third the length of the glabella from behind would pass through them, and they are distant from the side of the glabella about the width of the neck segment. The front of the neck is surrounded by a narrow border which appears to be flat; there appears to be some evidence of a spine on the neck segment.

"The pygidium found in the same fragment of stone with one of the specimens of the glabella of this species is in all general characters that of a *Bathyurus*. It is semicircular, convex, axis cylindrical, strongly convex, terminating behind with an abruptly rounded descent, six annulations, the first three or four most strongly defined. The lateral lobes have four segments each, separated by strong rounded furrows; there is a narrow entire margin all round, with a distinct groove inside, which appears, however, to be interrupted at the end of the axis.

"The dimensions of the most perfect specimens are as follows:

"Glabella, length three and one-half lines; width at neck segment one and one-half lines, at the front two lines; distance of the eye from the side of the glabella one and one-half lines. The eye appears to be about three-fourths of a line in length.

"Pygidium, length three lines; width at anterior margin five and one half lines; width of axis one line.

"*Locality and formation.*—Anse au Loup, on the north shore of the Straits of Belle Isle. Limestone of the Potsdam group."

In the more arenaceous and calcareous layers of the upper portion of Parker's quarry the heads and pygidia of this species are quite abundant, and, on comparing them with the figure and description of *P. senectus*, we place them under that species.

The figure and description given by Mr. Billings require the presence of short obtuse glabellar furrows, and these we find on two specimens; ten other specimens of the head do not show them. In other particulars the head appears to be the same, and the associated pygidium is similar to that found with *P. senectus;* and, as they are from the same relative geologic horizon, I prefer to place the Vermont species under *P. senectus* rather than to make a new species for its reception. The species *Bathyurus parvulus* is associated with *P. senectus* at L'Anse au Loup, is almost identical in appearance with some specimens of the head of *P. senectus* as found in Vermont, and it is, as yet, uncertain whether the latter should be referred to *P. senectus* or *P. parvulus.* The condition of preservation is the cause of the two forms in the Vermont rocks.

P. parvulus is placed as a variety of *P. senectus*, as I am unable to clearly understand the type of *P. parvulus.*

In studying broken fragments of trilobites it is difficult to determine generic, much less specific, relations; but, from a study of the type of the genus Bathyurus, I do not think we can refer any known species from the Middle Cambrian to that genus.

In some respects this species approaches quite closely to *Corynexochus spinulosus* Angelin (Pal. Scan., p. 59, pl. xxxiii, figs. 9, 9*a*); but, until we have a more complete description and better figures of that species, it would be hazardous to make a generic identification.

Formation and localities.—Middle Cambrian, Georgia Formation. Parker's quarry, town of Georgia, and one and one-half miles east of Swanton, Franklin County, Vermont; also, on the Labrador coast, as mentioned above.

Genus SOLENOPLEURA Angelin.

Solenopleura Angelin, 1852. Pal. Scan., p. 26.

SOLENOPLEURA NANA Ford.

Plate xxvii, fig. 3.

Solenopleura Nana Ford, 1878. Amer. Jour. Sci., 3d ser., vol. xv, p. 126.

Original description.—"The largest and best-preserved specimen consists of a nearly perfect glabella and the greater portion of the fixed cheeks, and is but two lines in length. The glabella is nearly four-fifths the total length of the head and is especially characterized by its great relief. It is obtusely conical, slightly widest behind, and is well defined all around by the dorsal furrows. In a specimen two lines in length its highest point is nearly one and one-half lines above the base of the fixed cheeks. It is marked on either side by two or three faint furrows. The fixed cheeks are notably convex, but their relief does not exceed one-third of that of the glabella. The eyes are situated slightly in advance of the mid-length and are connected with the front of the glabella by an obscure ocular fillet. The distance from the eye to the glabella is nearly equal to the width of the glabella at the mid-length. The front margin is narrow and is bounded by a feebly convex rim, inside of which there is a narrow furrow which gradually deepens on either side of the median line in passing outward. Between this furrow and the glabella there is a somewhat angular ridge which widens in passing outward to the sutures.

"The course of the facial suture is nearly the same with that of *Solenopleura brachymetopa* of Angelin (Palæontologia Scandinavica, pl. xix, fig. 1), but is directed more inward in front of the eye. The neck furrow is continuous all across. The exact form of the neck-segment cannot be made out, owing to the damaged condition of all of the specimens at this point. It is seen, however, to be less elevated than in the majority of the species, not rising above the surface of the fixed cheeks. The entire surface is covered with a fine regular granulation."

Specimens in the United States Geological Survey collection show that the occipital segment rises towards the center to form the base of a short spine that projects backward and upward to the base of the tumid glabella. In a head 7^{mm} long the furrows of the glabella are shown very distinctly.

Formation and locality.—Middle Cambrian. Conglomerate limestone, on the ridge east of the city of Troy, New York.

Genus BATHYURISCUS Meek.

Bathyuriscus Meek, 1873. Sixth Ann. Rep. U. S. Geol. Surv. Terr., p. 484.

Bathyuriscus was proposed by Mr. Meek at the end of the description of *Bathyurus ? Haydeni* in event that the latter species was found to be non-congeneric with *Bathyurus extans*, the type of the genus Bathyurus. Mr. Meek says: "If further comparisons show it to be generically or subgenerically distinct from all of the groups mentioned, as I believe it to be, it may be designated by the name *Bathyuriscus*."

Having found that two other species are generically allied to *B. Haydeni* and distinct from any described genus, I refer them to Mr. Meek's genus; and from the three species, *Bathyuriscus Haydeni*, *B. producta*, and *B. Howelli*, the following description is drawn:

General outline ovate. Head medium size, semicircular. Glabella straight or slightly expanded in front, marked by three or four pairs of glabellar furrows. Eyes elongate. The facial sutures cut the anterior margin of the head a short distance each side of the line of the greatest expansion of the glabella, and extend obliquely inward to the anterior bases of the eyes; encircling the latter, they extend obliquely outward, cutting the posterior margin so as to leave a narrow elongate lateral limb. Free cheeks unknown.

Thorax with from seven to nine segments; axis strong; pleural lobes well defined; pleural groove broad.

Pygidium semicircular; axis strong and crossed by several furrows; lateral lobes marked by the extension of the furrows crossing the axis.

Hypostoma of *B. producta* irregularly ovate; broadest a little forward of the center; posterior marginal rim raised; a strong sulcus extends around inside the rim; muscular scars well defined.

In many respects the head is similar to that of the genus Olenoides; the thoracic segments recall those of Ptychoparia, and the pygidium might be taken for that of a species of Bathyurus, or perhaps Ogygia. The general assemblage of characters points to a generic type distinct from any known to the writer.

The geologic range of the genus is from the Middle to the Upper Cambrian. *Bathyuriscus producta* is associated with *Kutorgina pannula*, *Olenoides typicalis*, and *Ptychoparia Piochensis*, &c., in a band of shale 2,000 feet below a typical Upper Cambrian or Potsdam fauna, such as *B. Haydeni* is found with in Montana. The intervening strata between the two species in the Highland Range, Nevada, are massive limestones. (See Highland Range section, p. 34.)

BATHYURISCUS HOWELLI n. sp

Plate xxx, figs. 2, 2a.

General form ovate. Entire form of head unknown, but from the parts preserved it appears to have been semicircular. Glabella clavate, expanding in front of the second pair of glabellar furrows; posteriorly the sides are subparallel to the occipital segment; the posterior pair of glabellar furrows are directed obliquely backward nearly to the occipital furrow; the second pair are less obliquely inclined backward, and the third pair penetrate directly in, one-third the distance on each side. Occipital furrow well defined; occipital ring rounded and rather strong. Eyes large, lunate, the extremities close to the glabella. Fixed cheeks very narrow; postero-lateral limbs narrow elongate; frontal limb narrow, slightly convex, and expanding but little in front of the glabella. The facial sutures cut the anterior margin and trend obliquely in to the anterior end of the eyes; encircling the large palpebral lobes, they extend outward from the posterior ends of the eyes and cut the posterior margin of the head well out towards the genal angle. Free cheeks unknown.

Thorax with eight segments. Axial lobe convex, tapering very gradually from the anterior segments to the pygidium; each segment is well defined and arches slightly forward; pleural lobes moderately convex; the segments curve gently backward from the genal angle and terminate in short falcate points; pleural groove rather broad and deep, and continued nearly to the extremity of the segment.

Pygidium subelliptical in outline; axis prominent, elongate, subconical, divided by four transverse furrows into four rings and a terminal segment; the pleural lobes are less convex, and, towards the margin, flattened out so as to form a broad, slightly convex border across which the four anchylosed segments, with their pleural grooves well defined, extend nearly to the margin.

Surface not preserved so as to show any surface striæ.

Dimensions: Length of entire body, 23^{mm}; head, 9^{mm}; thorax, 8^{mm}; pygidium, 6^{mm}.

The pygidium of this species is much like that of several referred to the genus Bathyurus, but in all other characters it is far outside that genus.

From the associated species, *B. producta*, it differs in having a different type of frontal margin to the head and in the extension of the pleural groove of the thoracic segments out nearly to their extremities. The pleural lobes of the pygidium also show the anchylosed segmental division much more strongly. The difference of one segment would not be of specific value in all cases, but, united with the other differences, it serves to distinguish the species.

The type specimen is the only one yet discovered that shows head, thorax, and pygidium. It is entire, with the exception of the free cheek, and the form is but slightly compressed.

Formation and locality.—Middle Cambrian. In an argillaceous shale at the Chisholm mine, on the southwest face of the Ely Mountains, near Pioche, Nevada. A pygidium was found in the Highland Range section twenty miles farther West.

BATHYURISCUS PRODUCTUS H. & W.

Plate xxx, figs. 1, 1*a–i*.

Ogygia producta Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 244, pl. ii, figs. 31–34.

Ogygia parabola Hall & Whitfield, 1877. Geol. Expl. Fortieth Par., vol. iv, p. 245, pl. ii, fig. 35.

The original description of the species is unsatisfactory, as it is drawn from imperfect material. I have before me all the type specimens, also a large collection made by Mr. J. E. Clayton for the Wheeler Survey, and a collection obtained the past season in the Highland Range of Central Nevada, where the stratigraphic position of the fauna was determined; the same horizon was also found in Big Cottonwood Cañon of the Wasatch Range in this same relative position just above the *Olenellus Gilberti* zone.

Form ovate. Head of medium size and nearly semicircular; margin bordered by a narrow rim that, at the genal angles, is prolonged into a rather strong spine. Glabella elongate, and expanding slightly near the anterior end of the eyes and on towards the front, where it is broadly rounded; three pairs of furrows are well defined on small specimens and more faintly shown on the larger heads; the posterior pair penetrate obliquely backward nearly to the occipital furrow; the second and third pair extend transversely about one-third the distance across; the third pair are opposite the anterior end of the eyes. Occipital furrow well defined, both across the glabella and out on the lateral limbs; occipital segment broad and convex in uncompressed specimens. Frontal limb narrow and usually little more than a thickened rim. Fixed cheeks narrow and, except on the postero-lateral limb, almost obsolete. Free cheeks subtriangular, rather large, and produced posteriorly in the genal spines of the head.

Thorax with seven segments; axis moderately convex; gradually tapers from the anterior segment posteriorly; segments well defined; pleural lobes gently convex; the pleuræ curve backward near their pointed extremities; pleural groove broad and distinctly marked about two-thirds the distance out from the axis; the flattened extremity shows no trace of it.

Pygidium broad, subelliptical in outline; proportions of length and breadth varying very much, owing to distortion by compression in the shaly matrix; the normal form appears to be less than twice as wide as long; axial lobe less than one-third the width anteriorly and tapering gradually to the posterior extremity, which is about one-fifth the distance of the length of the pygidium from the posterior margin; margin rather broad and usually well defined; axis marked by about six rounded rings, that vary in strength in different specimens; pleural lobes depressed convex and marked by four or five pleural grooves on well-preserved specimens. The surface characters are usually destroyed, but on some of the better-preserved specimens it is seen to have been very delicate and much like that of the genus Olenellus, having inosculating, subimbricating striæ over nearly all portions of the test except on the free cheeks, where irregular lines radiate from the base of the eyes to the margin.

We rarely meet with a species that shows a greater variation in the form and character of the glabella and pygidium than this; it all appears to be owing to the extent of the maceration of the shell before the solidifying of the sediment, the character of the sediment, and the subsequent distortion by compression and lateral movement in the matrix. The several figures tell the story better than any description. On the specimens showing the broad rim, the grooves are removed by compression and the reflex margin or doublure beneath gives the outline to the rim on the upper surface. On the better-preserved specimens, the axial rings, pleural grooves, and margin show much as when in their original condition.

It was owing to these distortions that Messrs. Hall and Whitfield were led to describe a second species, *Ogygia parabola*, from the imperfect material at their command. The study of the variation of form under different conditions of preservation is an essential one and is often disregarded by paleontologists, more especially in relation to the greater or less convexity of form. This remark is caused by reading the description of trilobites preserved in shales when the form is given as depressed, flattened, &c., as a specific character.

Formation and localities.—Middle Cambrian. Just above the Olenellus-bearing strata, one mile below Argenta in Big Cottonwood Cañon; also, at City Creek, Wasatch Mountains; East Cañon, Oquirrh Mountains, Utah; and at the Olenoides horizon, 2,000 feet below the Potsdam horizon of the Highland Range section, near Pioche, Nevada.

Genus ASAPHISCUS Meek.

Asaphiscus Meek, 1873. Sixth Ann. Rep. U. S. Geol. Survey Terr., p. 485, foot-note, 1872.

Original description.—"Asaphicus differs from the typical forms of Bathyurellus Billings, to which it is nearly allied, "in having its conical glabella *decidedly depressed* and the margin of the head in front of it first convex and sloping forward into a deep transverse mesial furrow, then rising in the form of a convex margin to the front. The mesial lobe of its pygidium is also proportionally longer, and the free margins of the same much narrower and less flattened and alate. It probably only forms a subgenus under *Bathyurellus*. From *Asaphus*, with which it agrees in general form and proportions, it differs in its decidedly conical, well-defined glabella, without lateral furrows or lobes, the extended and transversely furrowed character of the anterior margin of its head, its less arcuate eyes placed more remote from the glabella, and particularly in having nine body segments, instead of only eight. As in *Asaphus*, its pleuræ are distinctly furrowed, but they are more pointed than is usual in that genus, though not falcate. Its surface is smooth.

"The generic and specific characters will be given in full, with illustrations, in Lieutenant Wheeler's Report.

"Several American species with a similar depressed, conical glabella, without traces of lateral furrows or lobes, have been described from more or less complete specimens of the head, under the name *Conocephalites*. It is evident, however, from its smaller number of body segments, large pygidium, and differently formed plural grooves, that *Asaphiscus* is entirely distinct from that group."

From reading the descriptions of the genera Bathyurus, Bathyurellus, and Asaphiscus, I considered that the two latter genera had been separated on specific rather than generic characters (Twenty-eighth Ann. Rep. N. Y. State Mus. Nat. Hist., p. 94, 1879), but now that I have examples of the typical species of Bathyurus (*B. extans*) and Asaphiscus (*A. Wheeleri*) before me their generic differences are readily appreciated. The pygidium of Asaphiscus is identical in character with that of Bathyurus, and from the pygidium alone the reference would be to Bathyurus. The head, however, shows strongly marked differences, as mentioned by Mr. Meek. With Bathyurus it is more difficult to decide.

Mr. Billings gives as a distinction between Bathyurus and Bathyurellus that the latter has a conical or pointed glabella without traces of glabellar furrows, while Bathyurus has a subcylindrical glabella, rounded in front and marked by obscure furrows, "the pygidium of which also differs in not being strongly convex, in having a shorter axis, and in general a wider border."

Another marked difference between the two genera is in the configuration of the frontal limb; it also occurs between Bathyurellus and Asaphiscus; this, together with the differences in the pygidium, serves to distinguish the two latter.

When reviewing the Potsdam fauna, the relations of the genera Bathyurus and Bathyurellus will be discussed and figures of the typical species given.

ASAPHISCUS WHEELERI Meek.

Plate xxxi, figs. 3, 3*a*.

Bathyurellus (*Asaphiscus*) *Wheeleri* Meek, 1873. Sixth Ann. Rep. U. S. Geol. Surv. Terr., p. 485, foot-note, 1872.

Asaphiscus Wheeleri White, 1875. Geog. and Geol. Expl. and Surv. West 100th Merid., p. 43, pl. ii, figs. 1 *a–f*.

The description of this species by Mr. Meek has already been given under the genus Asaphiscus. Subsequently Mr. C. A. White described the species from the type specimens as follows:

"Body oblong-ovate in outline; surface smooth. Head depressed convex; front margin regularly rounded; postero-lateral angles abruptly rounded, without cheek spines; exterior margin bent shortly upward all around, producing a raised border of considerable width, and also a rather deep linear depression, or groove, parallel with that border and between it and the remainder of the cheeks. Glabella conical, much wider behind than in front, depressed; space between its anterior end and the marginal groove about equal to the width of the raised marginal rim in front of it; outline well defined by the narrow dorsal furrows; sides nearly straight; anterior end abruptly and posterior end broadly rounded, without lateral furrows, or at least they are hardly discernible; occipital furrow shallow, broad, but somewhat distinct and uniform, extending entirely across the glabella, and continuous with furrows similar to itself that extend to the postero-lateral angles of the head; the latter furrows lie parallel with and near to the posterior margin of the head, giving that margin also a raised border, somewhat like the one upon the exterior margin. Eyes comparatively small, crescentic, situated nearly opposite the mid-length of the glabella, and nearly equidistant from it and the posterior margin.

"Thorax having nine segments; its length not quite so great as that of the head; axis broadest anteriorly, more strongly convex, and about one-third narrower than the lateral lobes are; segments extending straight across the lobe; lateral lobes depressed, their greatest convexity along the middle; pleuræ bluntly pointed at their outer ends, the points not being directed very strongly backward; their inner ends so joined to the axial segments that they have the appearance of lapping a little upon them just inside the dorsal furrow; grooved, the groove being deepest about mid-length, where the outer and inner portions of its front border meet at a distinct but very obtuse angle; grooves extending from the dorsal furrow nearly to the extremity of the pleuræ, where they disappear.

"Pygidium somewhat semicircular in outline, distinctly trilobate; segmentation indistinct, so much so in some of the specimens that the surface appears nearly as plain as that of an *Asaphus*, but the segmentation is usually more distinctly shown upon surfaces from which the crust has been removed; axis prominent, especially at its distal end, where it terminates abruptly at the inner edge of the broad marginal border; segments of axial lobe eight or ten; lateral lobes much depressed, a little wider than the axial lobe at the anterior end, and narrowing to an incurved point at the end of the axis; the whole exterior margin having a broad, flat border of nearly uniform width throughout; the under surface of this border marked by fine, somewhat irregular, longitudinal striæ, such as are usually seen upon corresponding parts of *Asaphus*.

"The largest specimen in the collection is about seven centimeters long.

"These specimens are the same that were used by Mr. Meek in his description of this species, and upon which he also based his genus *Asaphiscus*."

All the specimens are more or less flattened by compression; but from a few that show portions of the original convexity it is proven to have been about as in the genus Bathyurus. The strongly marked border of the pygidium also arises from the compression of the doublure up against the upper surface. In an uncompressed specimen the slope from the central axis to the margin is unbroken by any marked line.

Formation and localities.—Middle Cambrian. House Range, Antelope Springs, Utah. An identical form of pygidium also occurs at Pioche, Nevada, associated with *Olenoides typicalis*.

Genus DORYPYGE Dames.

Dorypyge Dames, 1883. China, Richthofen, vol. iv, p. 23.

It was not until the last pages of this report were put in type that I had the opportunity of reading Dr. Dames's description of the genus

Dorypyge and his reference of *Dikellocephalus quadriceps* and *D. gothicus* of H. & W. to that genus (China, Richthofen, vol. iv, p. 24).

On pages 187 and 189, I have placed the two species under the genus Olenoides while waiting for proof of the character of the border of the pygidium of the genus. I have very little doubt of its being spinous, and if it is so the species described by Dr. Dames will probably fall within its limits, and the genus Dorypyge be placed as a synonym of Olenoides.

In the event of *Olenoides Nevadensis* being generically distinct from *Dorypyge Richthofeni* Dames, then *Olenoides typicalis*, *O. Marcoui*, *O. spinosus*, *O. levis*, *O. flagricaudus*, *O. expansus*, *O. quadriceps*, and *O. Wahsatchensis* may be referred to the genus Dorypyge.

It is hoped that this question will be settled during the present year by the acquisition of large collections of fossils from the typical localities in Utah and Nevada.

DESCRIPTION OF A PTEROPOD FROM THE UPPER CAMBRIAN.

PTEROPODA.

Genus MATTHEVIA Walcott.

Matthevia Walcott, 1885. Amer. Jour. Sci., 3d ser., vol. xxx, p. 17.

Shell conical; aperture sinuous; transverse section ovate, elliptical, or rounded subquadrate; interior with two elongate chambers diverging from the apex and opening into a large, single, terminal chamber; both of the interior chambers are crossed by a single imperforate septum; calcareous; surface papillose. Operculum calcareous, nucleus eccentric, lines of growth concentric.

Type, *Matthevia variabilis.*

The generic name is proposed in honor of Mr. G. F. Matthew, who is doing so much good work on the St. John Cambrian fauna.

This peculiar shell is so distinct from all described forms referred to the Pteropoda that a new family, Matthevidæ, is instituted to receive the one genus now known.

In form and surface markings it approaches the genus Conularia; the operculum may be compared to that of Hyolithes and the imperforate transverse septum allies it to both Hyolithes and Conularia. Its thick shell is observed in the genera Conularia, *C. fecunda* Barr. (Syst. Sil. Bohême, vol. iii, pl. viii, fig. 8); Hemiceras, *H. cylindricus* Eichwald (Lethea Ross., vol. i, atlas, pl. xl, fig. 17; pl. xlii, fig. 29); and Hyolithes, *H. impar* Ford (this Bulletin, pl. xiv, fig. 1). When we come to trace a relationship to the two inner chambers, we are at once at a loss for comparisons. The genus Pterotheca has a shelf-like projection that may indicate a division of the animal, and we may look to the shelf-bearing gasteropods, Crepidula, &c.; but, while these may indicate the origin of the dividing shell between the two chambers of Matthevia, the latter remains clearly and distinctly a type by itself.

There is a curious form described as *Tetradium*[1] *Wrangeli* Schmidt (Mém. Acad. Imp. Sci., St.-Pétersbourg, viie sér., t. xxi, No. 11, p. 42; t. iv, figs. 3–8, 1874), which Lindstrom suggests is by the thick-shelled *Conularia fecunda* linked to the Conulariæ and made to stand in affinity to them (Sil. Gasteropoda and Pteropoda of Gotland, p. 41, 1884).

[1] The genus Tetradium being preoccupied (Dana, 1846; Safford, 1856), I propose Palænigma in place of Schmidt's Tetradium, 1874, for the species under discussion. *P. Wrangeli.*

From our comparisons Matthevia appears still more to serve as a connecting link between Palænigma and the genera Conularia and Hyolithes. If *P. Wrangeli* had chambers running up into the shell, as is suggested by the cross-sections, and a septum that caused the upper portion of the shell to be decollated, as we are led to believe by the natural section shown by fig. 2*b*, pl. xxxiii, and by the fact that each specimen has lost its apex, the relations between Palænigma and Matthevia are quite close, and Palænigma may be, provisionally at least, grouped with the Paleozoic genera Matthevia and Conularia.

MATTHEVIA VARIABILIS Walcott.

Plate xxxii, figs. 1–12; pl. xxxiii, figs. 1, 1*a–f*.

Matthevia variabilis Walcott, 1885. Amer. Jour. Sci., 3d ser., vol. xxx, p. 18, figs. 1–6 of p. 20.

On a side view the outline of the shell varies from broad to narrow conical, and the end view shows an elongate-conical to a broad-conical outline; the cross-section varies from elliptical to oval to rounded quadrangular; aperture varies in outline with the proportions of the shell; a sinus, varying in depth and curvature, extends across the ends of the shell; in the more elliptical apertures the sides are nearly straight and parallel, while in those with a subquadrangular outline they are strongly curved, and the sinus at the ends is very profound. A longitudinal cross-section shows, in the larger number of shells, a section similar to that represented by fig. 1*a* of plate xxxiii; figs. 1, 1*b*, 1*d*, exhibit the variations in section taken at the same place in different shells that vary in outline. The shell thins out at the edges and is not thick over the exterior of the interior chambers, but between them a connecting mass of shell unites the sides and gives strength and solidity; a section crossing the center of the shell at right angles to the preceding shows a solid shell to the outer chamber, where it gradually thins out to the margin. The positions of the two inner chambers vary in relation to each other, as may be seen in the figures, from subparallel to widely divergent; the chamber that is more at right angles to the aperture than the other is usually larger and is always prominent, while the oblique chamber is sometimes filled up by shelly matter and only the outer portion remains; both chambers are usually flattened on the inner side and more or less expanded where they enter the large outer chamber. The septum crossing the inner chambers is thin and varies in shape with the form of the chambers; it is usually slightly concave-convex, concave towards the outer chamber, and marked, usually, by a raised scar of varying character, as is shown in the figures; the septum is usually a short distance from the outer chamber, 1^{mm} to 4^{mm}.

The substance of the shell is calcareous, and in thin sections appears to be vesiculose, as in figs. 1*e*, 1*f*, of plate xxxiii.

Surface marked by undulating lines of growth parallel to the margin of the aperture, a few radiating lines usually on the sides, and several fine papillæ arranged in lines that cross each other at right angles on some shells; on others the papillæ are arranged in lines parallel to the lines of growth and without reference to the order of those in the adjoining lines; the interior surface is covered with a fretted surface brought out by depressed, irregular, inosculating lines; this surface varies in force and character, and some shells are almost smooth inside; a narrow, smooth space extends all around the margin of the inside of the aperture.

The associated opercula vary in form and outline; the shell is calcareous, concavo-convex, rising to a blunt point more towards one end than towards the other; from this point, which is the center of the concentric undulations of growth, narrow, radiating undulations extend to the margin. Surface with concentric and radiating undulations; fine inosculating lines subparallel to the concentric undulations and fine papillæ on the spaces between the inosculating lines; interior surface convex, smooth, or showing the undulations of the outer surface; at the center, corresponding to the apex of the outer surface, a small round scar appears to be indicated on some specimens.

There are two forms known to me that correspond in a measure to this: one is that figured by Eichwald (Lethea Ross., pl. xl, fig. 19*a–c*) as *Hyolithes paradoxodus*, which appears to be the cast of a portion of the outer chamber and one of the conical inner chambers; it may be, however, only a superficial resemblance. The second was discovered when examining the type of *Metoptoma anomala* Billings (Pal. Foss., vol. i, p. 89), in the collection of the Geological Survey of Canada. I found it to be the cast of the chamber of habitation of some species of Matthevia. It may be that of *M. variabilis*, but it is impossible to identify it from the specimen. It was found in a bowlder of limestone at Point Levis, Canada.

Formation and locality.—Upper Cambrian. Limestone resting on Potsdam sandstone, one mile northwest of Saratoga Springs, New York.

The species is associated with *Cryptozoa poriferum* Hall (Thirty-sixth Ann. Rep. N. Y. State Mus. Nat. Hist., description of pl. vi, 1884), *Platyceras minutissimum* Walcott, *Ptychoparia* (*L.*) *calcifera* Walcott, *Dicellocephalus Hartti* Walcott, and *D. speciosus* Walcott.

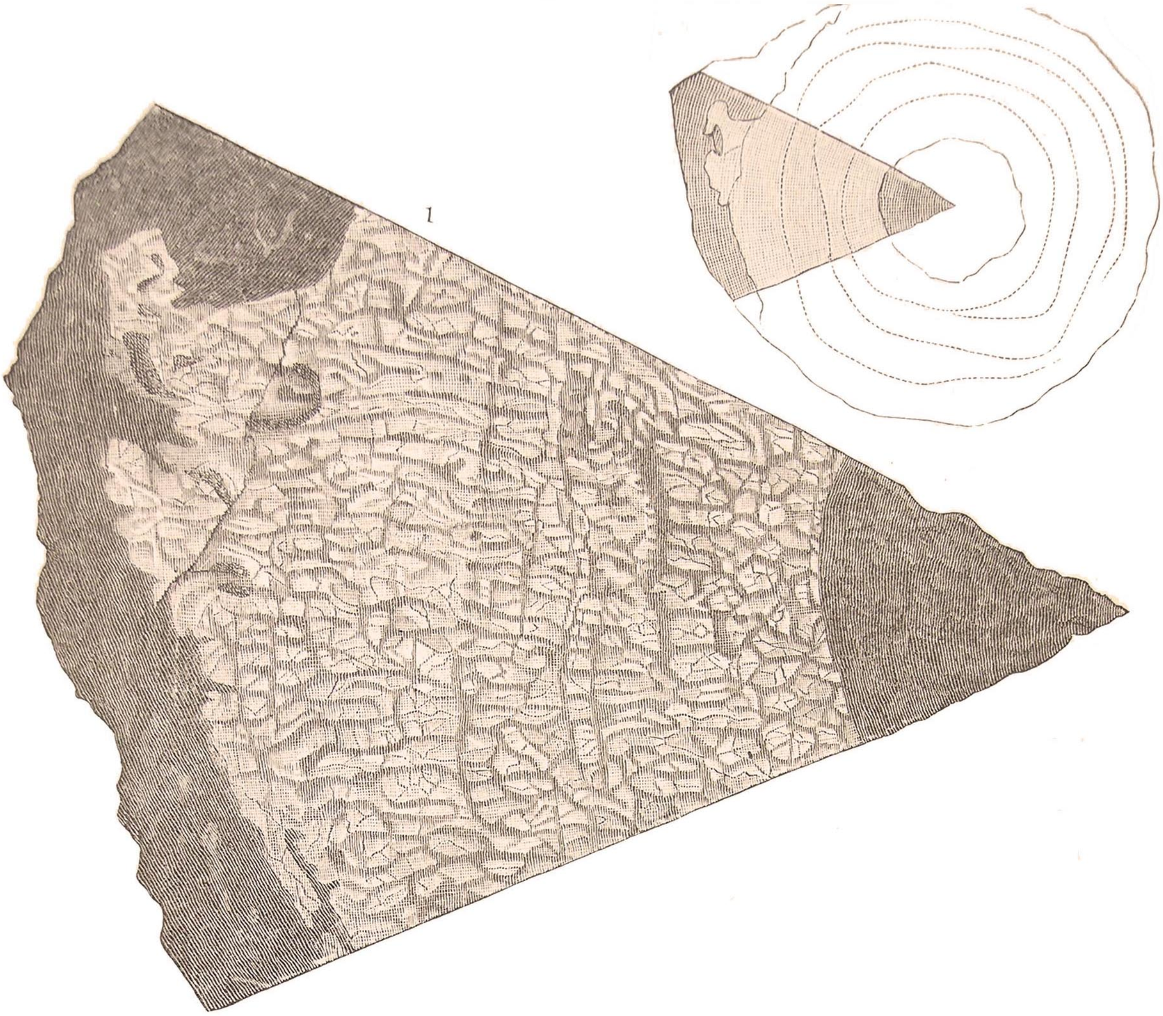
THIS PAGE BLANK

INDEX.

[Figures in heavy-faced type indicate the page on which the description is given or important mention is made.]

A.

Z.



1

1*d*

1*c*

PLATE I.

Page.

Fig. 1. ETHMOPHYLLUM PROFUNDUM 84

1. Enlargement of a portion of a transverse section of specimen in which the growth appears to have been in layers. Collection U. S. National Museum.

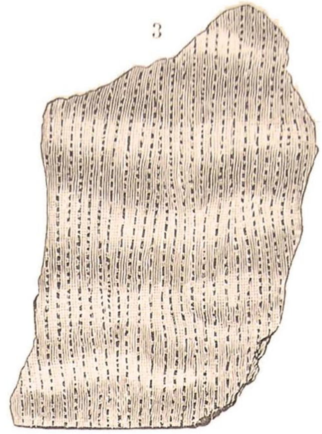
1*a*. Outline of the section from which fig. 1 was enlarged.

1*b*. Enlargement of a portion of the section shown by fig. 3*b* of plate ii. The vesiculose structure is well shown. Collection U. S. National Museum.

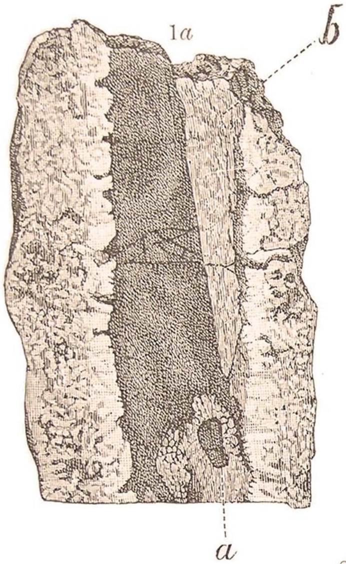
1*c*. Section of solid stem. Natural size. Collection U. S. National Museum.

1

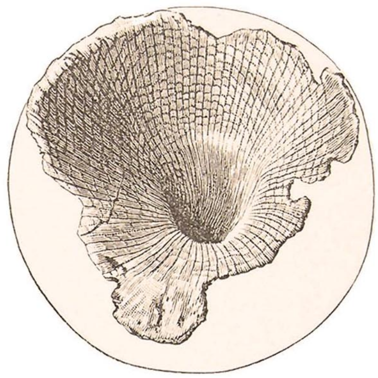
3



1a



3a



2a

2

3b

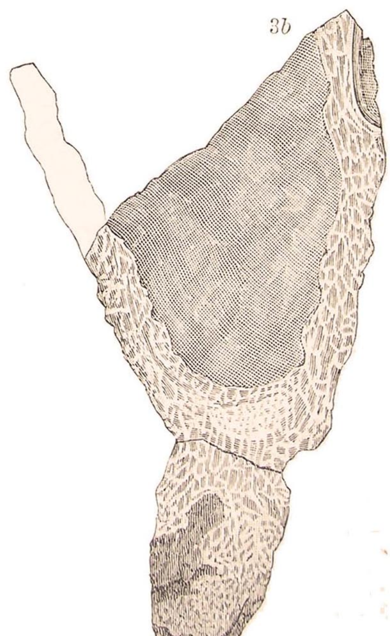


PLATE II.

1. Transverse section of the type specimen now in the Museum of the Geological Survey of Canada.

1*a*. Longitudinal section of 1. At "*a*" the growth within the cup, spoken of in the text, is shown. The elongate body, "*b*," is probably a foreign body introduced into the cup.

2. View of the type specimen. Natural size.

2*a*. Enlargement of a portion of 2, between the dotted lines. Collection U. S. National Museum.

3. Portion of a cast of the interior of the outer wall, showing the openings in the septa. Collection U. S. National Museum.

3*a*. View of the cup of a small specimen. Collection U. S. National Museum.

3*b*. Longitudinal section showing the depth of the cup and the vesiculose character of the space between the walls. An enlarged view of the lower portion of this figure is shown on pl. i. Collection U. S. National Museum.

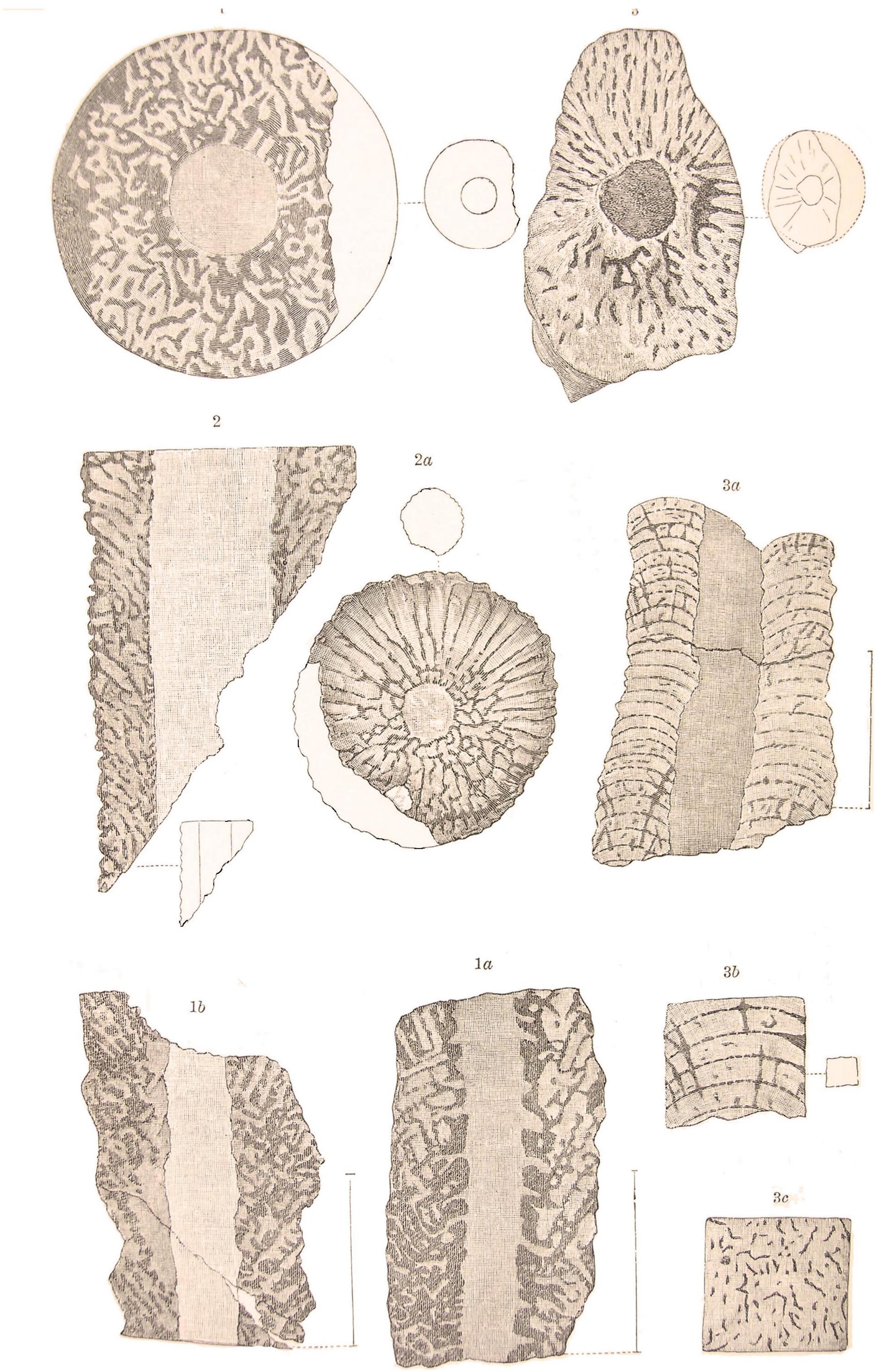

1
3
2
2a
3a
1b
1a
3b
3c

PLATE III.

Page.

Figs. 1, 2. ARCHÆOCYATHUS ATLANTICUS 73

1. Transverse section of specimen from L'Anse au Loup, Labrador, enlarged to show the irregular openings. Collection U. S. National Museum.

1*a*. Longitudinal section showing more regularity in the arrangement of the skeleton than in the type specimen, pl. ii, fig. 1*a*. Collection U. S. National Museum.

1*b*. Longitudinal section of a specimen from Silver Peak, Nevada.

2. Longitudinal section of specimen from Silver Peak that shows still more regularity in the interior structure than either 1*a* or 1*b*. Collection U. S. National Museum.

2*a*. Transverse section of fig. 2.

Fig. 3. ARCHÆOCYATHUS BILLINGSI 74

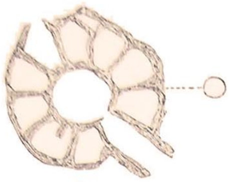
3. Transverse section of a small specimen. Collection U. S. National Museum.

3*a*. Longitudinal section showing the central cavity, transverse septa, etc. The outer walls are mostly worn away. Collection U. S. National Museum.

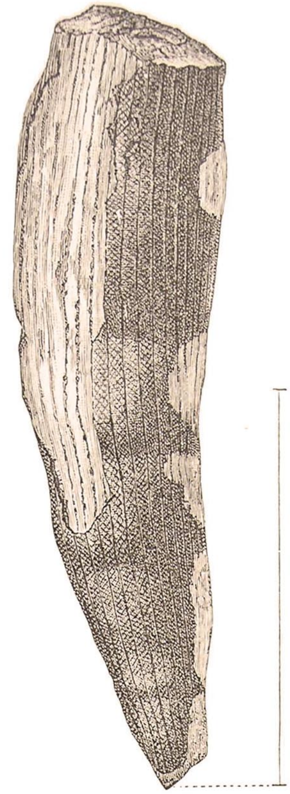
3*b*. Enlargement of a few transverse septa, showing the irregular vertical septa, pore openings in the septa, and the spicula-like pieces in the interseptal spaces.

3*c*. Enlargement of the spicula-like bodies in the cup and interseptal spaces.

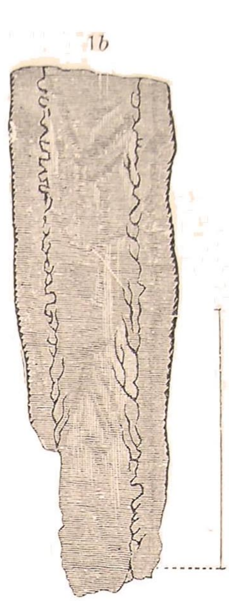
1d



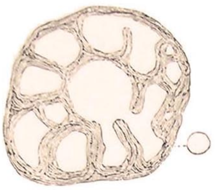
1



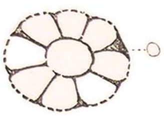
1b



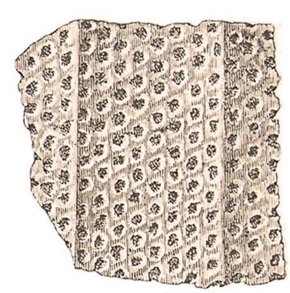
1e



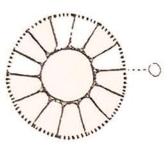
1f



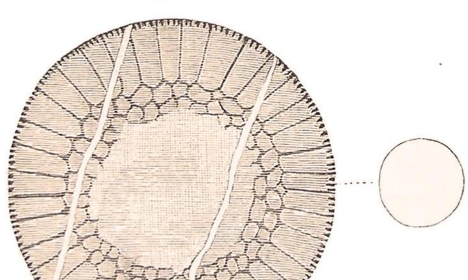
1a



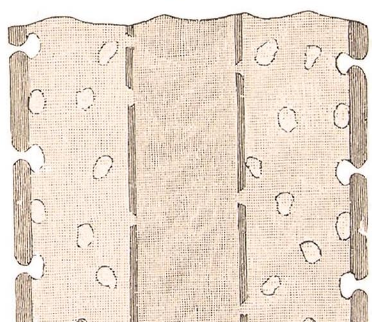
1g



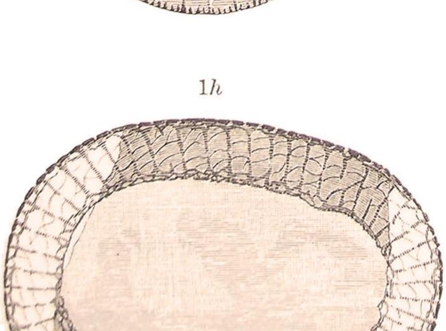
1c



2



1h



3

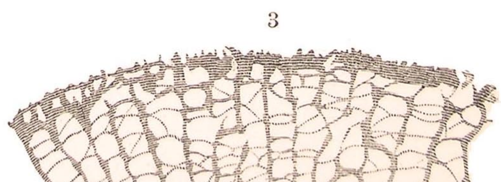


PLATE IV.

Page.

Fig. 1. ETHMOPHYLLUM WHITNEYI 81

1. Enlargement to two diameters of one of the type specimens. Collection U. S. National Museum.

1*a*. Enlargement of the outer surface to 10 diameters. Collection U. S. National Museum.

1*b*. Longitudinal section of a specimen showing the vesiculose inner wall, which, when the outer wall and septa are broken away, gives the form described by Mr. Meek as *E. gracilis*. Collection U. S. National Museum.

1*c*. Transverse section showing the structure mentioned of fig. 1*b* still more clearly; also, the septa and poriferous outer wall. 37 septa. Collection U. S. National Museum.

1*d*, 1*e*. Two transverse sections of a very small specimen, in which the walls and septa are thickened.

1*f*. Transverse section, 1.5^{mm} in diameter, showing eight septa. Collection U. S. National Museum.

1*g*. Similar section to 1*f*, with 14 septa. The two sections represented by figs. 1*d*, 1*e*, indicate irregular growth, and 1*f*, 1*g*, the uninterrupted, natural growth of the species. Collection U. S. National Museum.

1*h*. A larger transverse section, with 58 septa; numerous partitions between the septa, the outer poriferous wall, and the openings between the septa. Collection U. S. National Museum.

Fig. 2. ETHMOPHYLLUM 87

2. Diagrammatic vertical section through the center on the line of the septa, to show the writer's view of the poriferous system. If the outer wall is removed, the large pores on the line of the septum would be shown as in fig. 1, pl. iv, and fig. 2, pl. v. The inner wall is perforated by smaller openings, and fewer of them, than the outer wall.

Fig. 3. ETHMOPHYLLUM PROFUNDUM 84

3. Enlargement of a portion of the section represented by fig. 1, pl. i, to show the complicated structure more clearly.

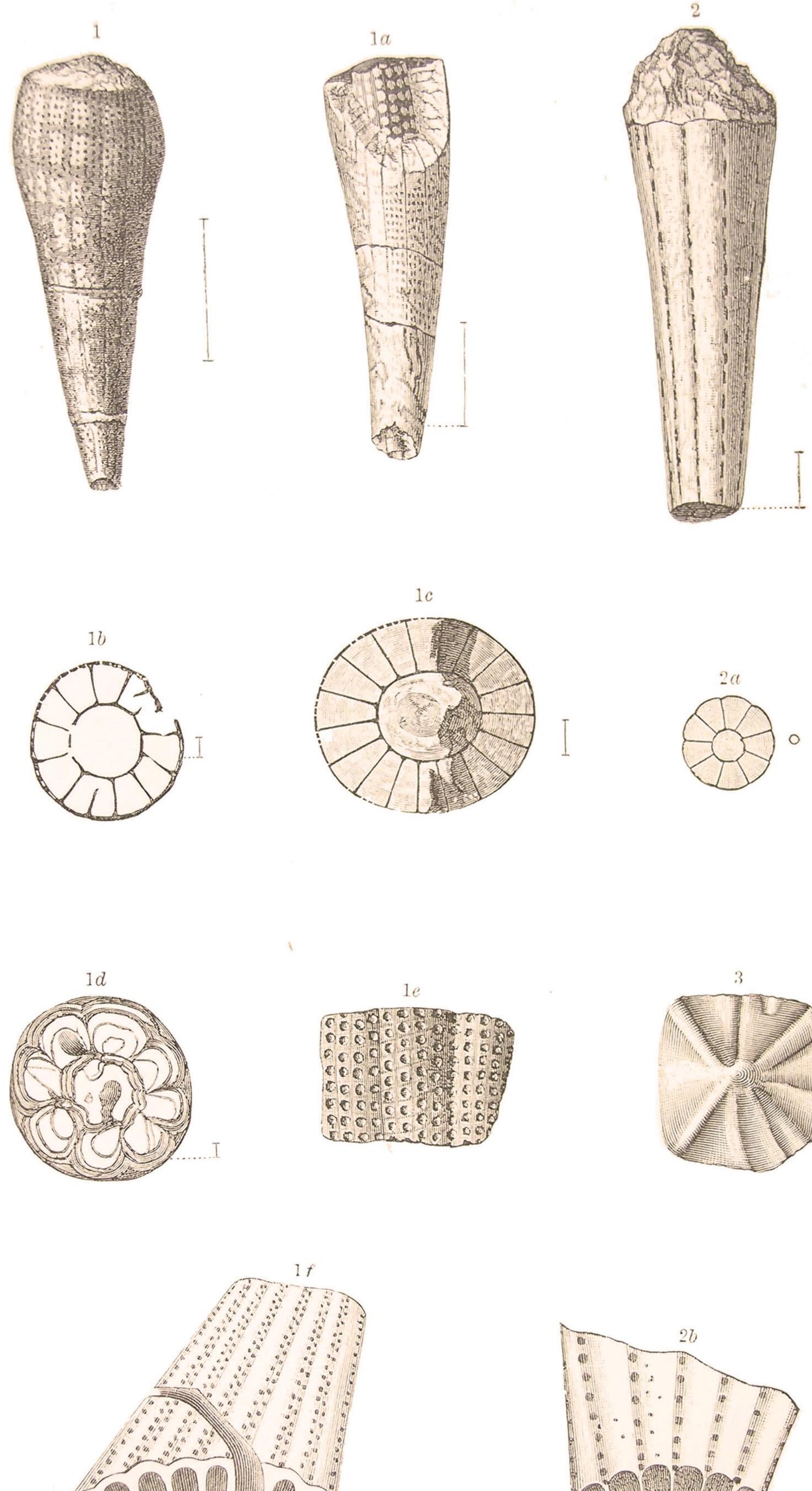

1
1a
2
1b
1c
2a
1d
1e
3
1f
2b

PLATE V.

Page.

Fig. 1. ETHMOPHYLLUM RENSSELAERICUM 85

1. A nearly perfect specimen, showing the summit and the outer poriferous surface. Collection U. S. National Museum.

1*a*. A specimen with portions of the outer wall removed, so as to show the septa and the poriferous surface of the inner wall. Collection U. S. National Museum.

1*b*. Transverse section showing 12 septa and the pores of the inner and outer walls, enlarged. Collection U. S. National Museum.

1*c*. Transverse section of the upper end of 1*a*, with 18 septa. Collection U. S. National Museum.

1*d*. Transverse section, where the walls and septa are thickened by additional layers. Collection U. S. National Museum.

1*e*. Enlargement of the outer poriferous surface.

1*f*. Drawing of the type specimen, by Mr. S. W. Ford. The poriferous surface is worn off on the raised portion. I am not satisfied but the dissepiments are of accidental origin. There are about 20 septa in the transverse section of the specimen. Collection S. W. Ford.

Fig. 2. ETHMOPHYLLUM RARUM 87

2. View of the only specimen that can be referred to this species in the collection of the Geological Survey. The outer surface is entirely removed. Collection U. S. National Museum.

2*a*. Transverse section of the lower end of 2, showing 9 septa.

2*b*. Drawing of the type specimen, by Mr. S. W. Ford. There are about 21 septa and the outer surface is removed. Collection S. W. Ford.

Fig. 3. EOCYSTITES ? ? LONGIDACTYLUS 94

3. Enlargement of one of the plates occurring at Pioche, Nevada. Collection U. S. National Museum.

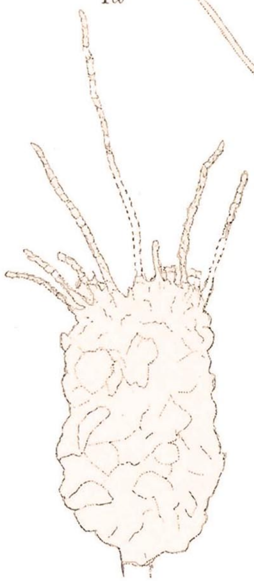
2

2a

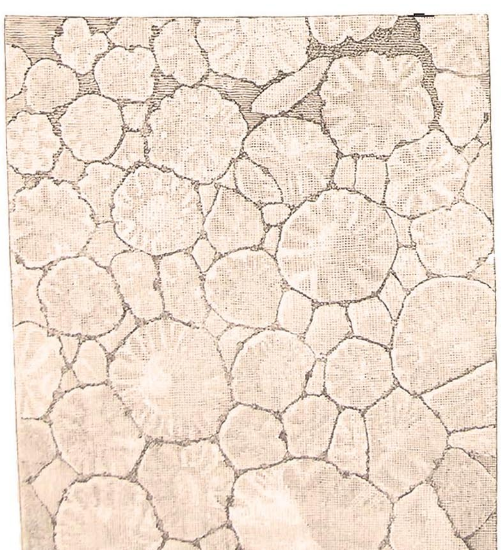
2b

1

1a



1c



1b

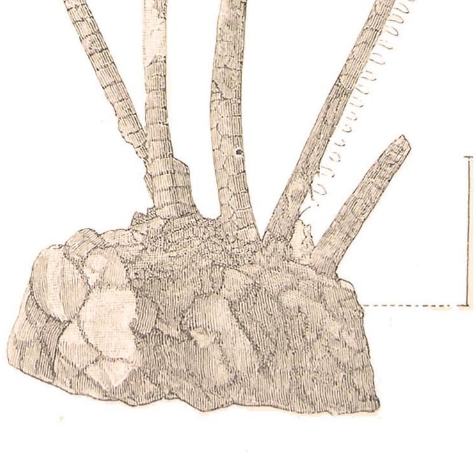


PLATE VI.

Page.

Fig. 1. EOCYSTITES ? ? LONGIDACTYLUS 94

1. Upper half of the body of a large specimen, preserving several of the long, slender arms. The summit is crushed on the right side, causing the arms to bunch together. Natural size. Collection U. S. National Museum.

1*a*. Outline figure, natural size, of a specimen with the plates crushed in on each other.

1*b*. Enlargement of the summit of a specimen from which the plates have been broken away, showing the structure of the arms and the casts of the short pinnulæ. Three times natural size. Collection U. S. National Museum.

1*c*. Enlargement of a group of plates from a large specimen, to show variation in size, outline, surface markings, and the differences in the openings or pores on the margins of the plates.

Fig. 2. PROTOSPONGIA ? FENESTRATA ? 90

2, 2*a*, 2*b*. Three forms of spiculæ. 2*a* is the form rarely met with. Collection U. S. National Museum.

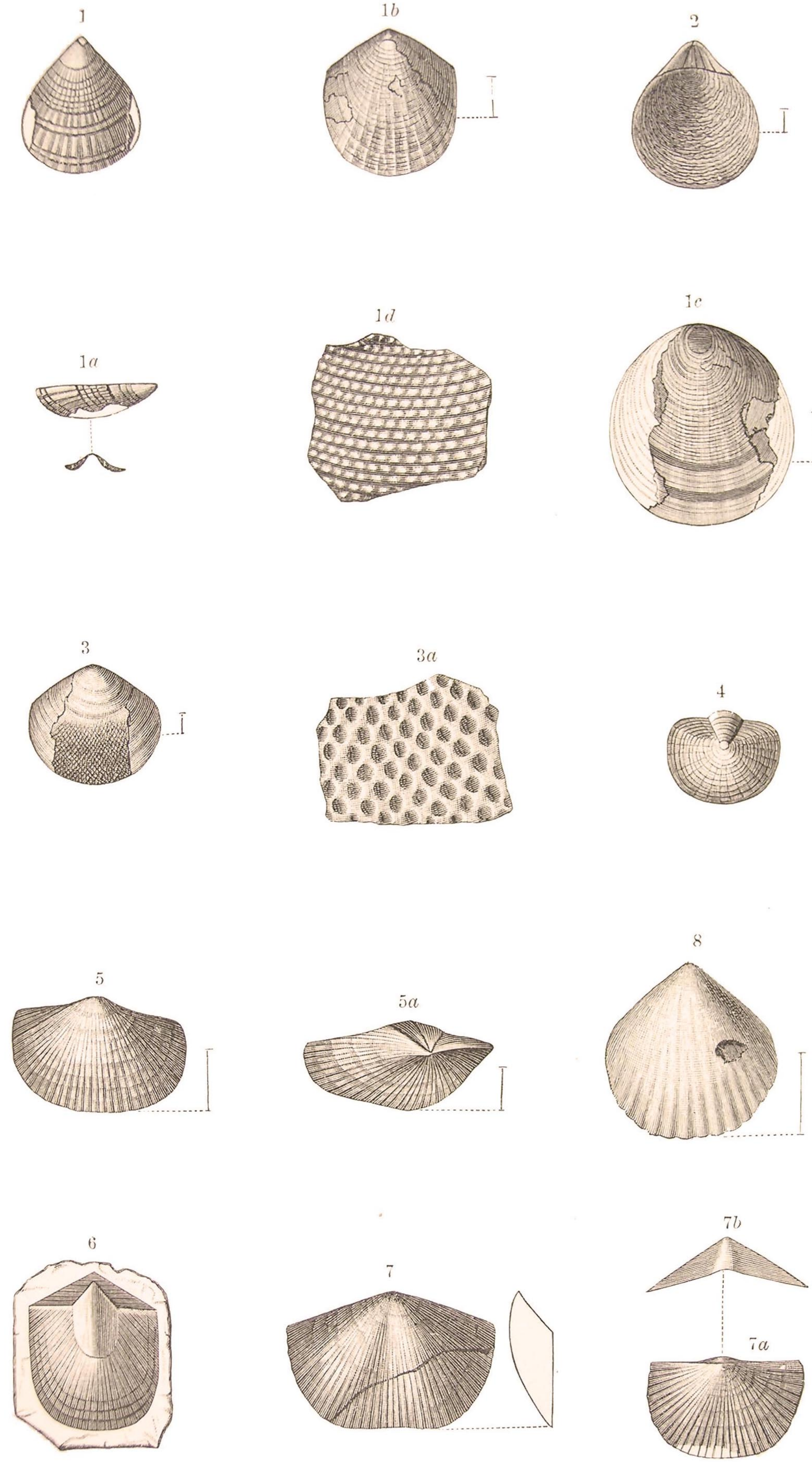

1
1b
2
1a
1d
1c
3
3a
4
5
5a
8
6
7
7b
7a

PLATE VII.

Page.

Fig. 1. LINGULELLA CÆLATA 95

1. Ventral valve, enlarged to 2 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

1*a*. Side view of same, with a view of the beak, looking from behind.

1*b*. Enlargement of a small dorsal (?) valve. Collection U. S. National Museum.

1*c*. Dorsal valve, enlarged. Collection U. S. National Museum.

1*d*. Surface of dorsal valve, greatly enlarged.

Fig. 2. LINGULELLA ELLA 97

2. Ventral valve, showing the area, deltidial opening, and cast of the exterior surface of the valve. Enlarged. See pl. viii. Collection U. S. National Museum.

Fig. 3. KUTORGINA PANNULA 105

3. Ventral (?) valve, enlarged. The type specimen. Collection U. S. National Museum.

3*a*. Enlargement of a portion of the surface of 3. See plate viii.

Fig. 4. IPHIDEA BELLA 100

4. Copy of the original figure given by Mr. Billings. Ventral (?) valve. Collection Geological Survey, Canada.

Fig. 5. ORTHISINA TRANSVERSA 121

5. Ventral valve, enlarged to 2 diameters. Collection U. S. National Museum.

5*a*. Another specimen, showing the area. Collection U. S. National Museum.

Fig. 6. ORTHISINA ORIENTALIS 120

6. Ventral valve, natural size. (After Whitfield.) Collection American Museum Natural History, New York City.

Fig. 7. ORTHISINA FESTINATA 120

7. Ventral (?) valve and outline, natural size. Collection U. S. National Museum.

7*a*. Dorsal (?) valve, enlarged. Collection U. S. National Museum.

7*b*. View of area of 7*a*. Collection U. S. National Museum.

Fig. 8. CAMARELLA (?) ANTIQUATA 122

8. Ventral valve, enlarged. Collection U. S. National Museum.

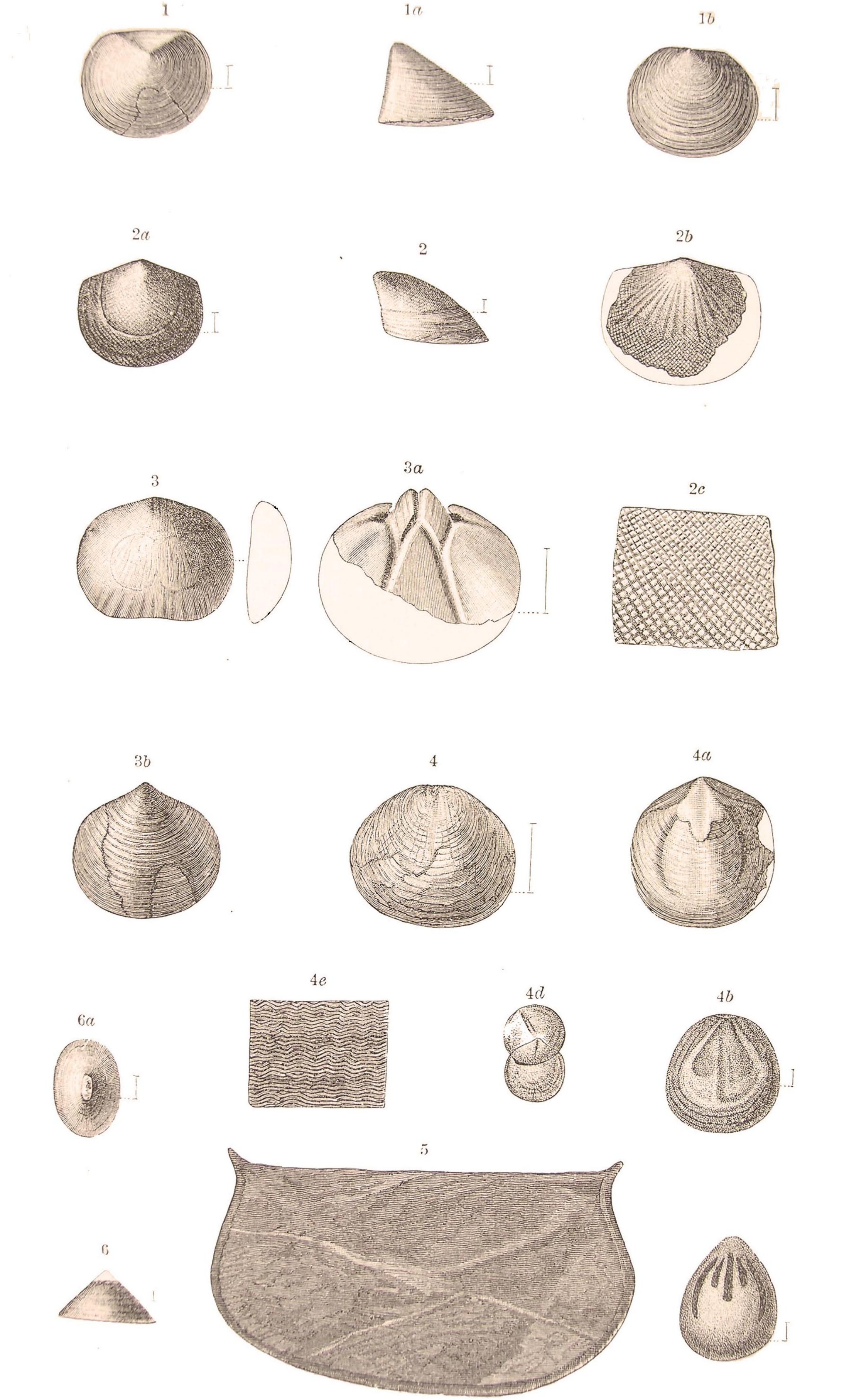

1
1*a*
1*b*
2*a*
2
2*b*
3
3*a*
2*c*
3*b*
4
4*a*
6*a*
4*e*
4*d*
4*b*
5
6

PLATE VIII.

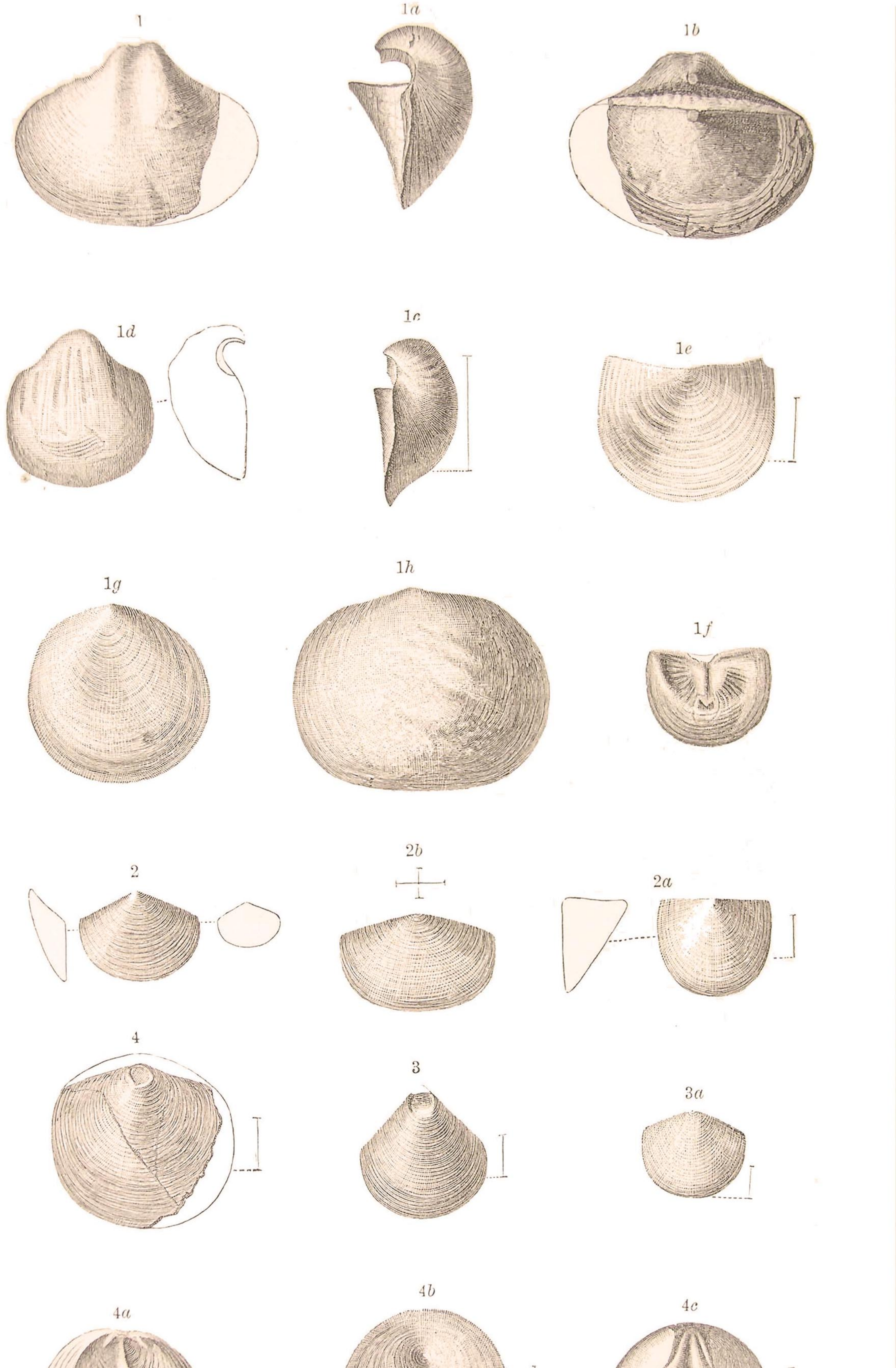

1
1a
1b
1d
1c
1e
1g
1h
1f
2
2b
2a
4
3
3a
4a
4b
4c

PLATE IX.

Page.

Fig. 1. KUTORGINA CINGULATA 102

1, 1*a*, 1*b*. Ventral, lateral, and dorsal views of a large shell that is mostly denuded of the outer surface. Collection U. S. National Museum.

1*c*. Lateral view of a small shell, to compare with 1*a*, the height of the dorsal valve being much less than that of 1*a*. Collection U. S. National Museum.

1*d*. Cast of the interior of the dorsal valve, showing muscular scars. Collection U. S. National Museum.

1*e*. Dorsal valve, enlarged. Collection U. S. National Museum.

1*f*. Interior of dorsal valve. Collection U. S. National Museum.

1*g*, 1*h*. Compressed shells from shales of Parker's quarry; probably ventral valves. Collection U. S. National Museum.

Fig. 2. KUTORGINA LABRADORICA 104

2, 2*a*. Ventral valves, enlarged. Collection U. S. National Museum.

2*b*. Dorsal valve, enlarged. Collection U. S. National Museum.

Fig. 3. KUTORGINA PROSPECTENSIS 106

3. Ventral valve, enlarged. Collection U. S. National Museum.

3*a*. Dorsal valve, enlarged. Collection U. S. National Museum.

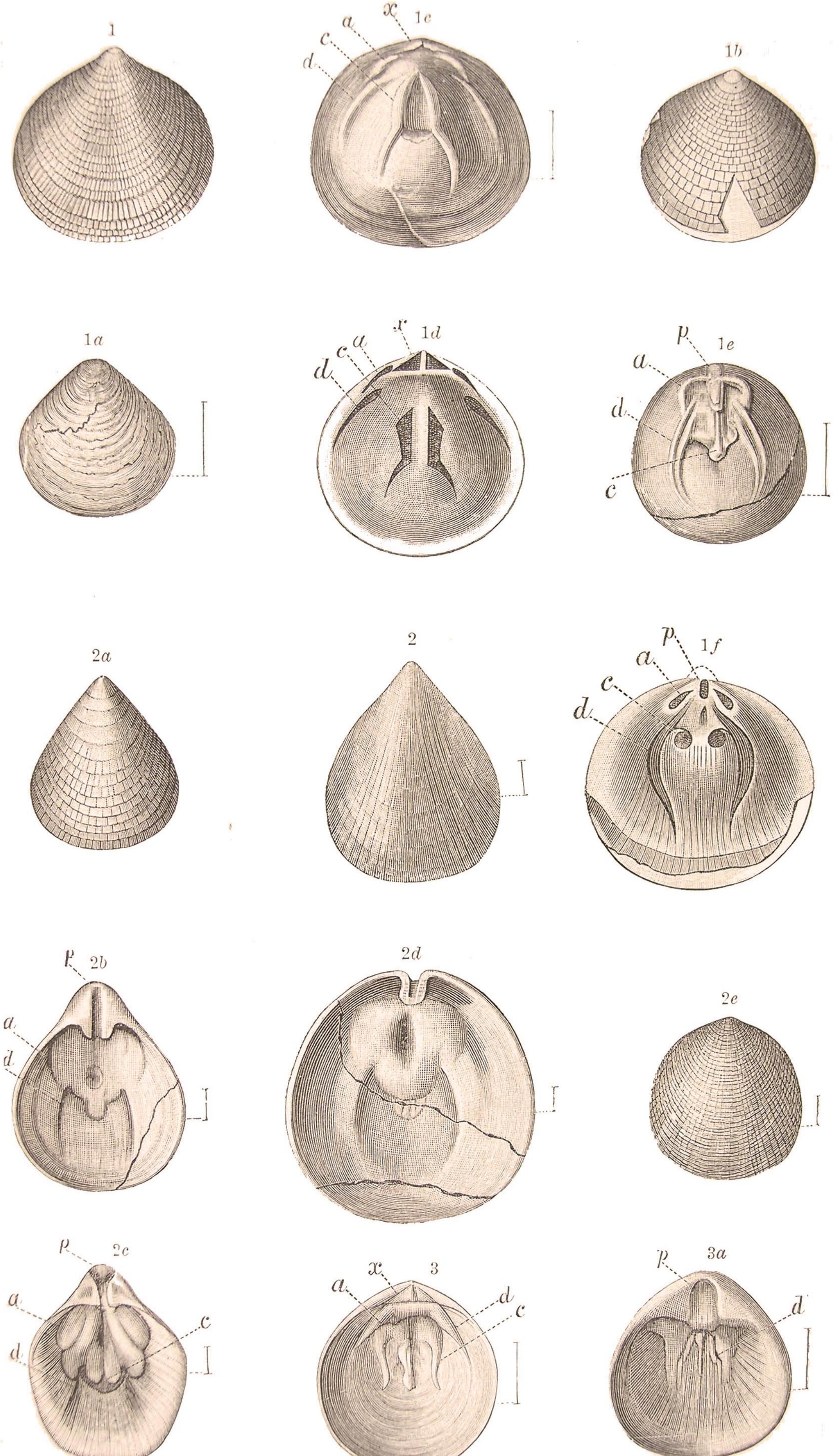
Fig. 4. ACROTHELE SUBSIDUA 108

4. Ventral valve from Pioche, Nevada, showing exterior surface, enlarged. Collection U. S. National Museum.

4*a*. Interior of dorsal valve, enlarged. Collection U. S. National Museum.

4*b*. Ventral valve from Antelope Springs, Utah, with exterior surface removed, enlarged. Collection U. S. National Museum.

4*c*. Cast of interior of dorsal valve, enlarged. Collection U. S. National Museum.



1
x
a
c
d
1c
1b
1a
x
1d
c
a
d
p
1e
a
d
c
2a
2
p
1f
a
c
d
p
2b
a
d
2d
2e
p
2c
a
d
c
a
x
3
d
c
p
3a
d

PLATE X.

1. Ventral valve, showing well-preserved exterior surface, enlarged to 3 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

1*a*. Dorsal valve, with the outer surface exfoliated, enlarged. Collection U. S. National Museum.

1*b*. Dorsal valve, preserving outer surface, enlarged to 2 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

1*c*. Cast of interior of dorsal valve; notation same as 1*d*. Collection U. S. National Museum.

1*d*. Diagrammatic drawing of the interior of dorsal valve. (Drawing by S. W. Ford.) *a*, cardinal; *c*, central, and *d*, lateral muscular scars; *x*, area.

1*e*. Cast of interior of ventral valve; notation same as 1*f*. Collection U. S. National Museum.

1*f*. Diagrammatic drawing of the interior of ventral valve. (Drawing by S. W. Ford.) *a*, cardinal; *c*, central, and *d*, lateral muscular scars; *p*, pedicle groove.

2. Exterior of a somewhat macerated specimen of the ventral valve, from Bic Harbor, enlarged. Collection U. S. National Museum.

2*a*. Ventral valve from Troy, New York, enlarged to 6 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

2*b*. Interior of ventral valve from Bic Harbor. *a*, cardinal; *d*, lateral, and *c*, central muscular scars; *p*, pedicle groove. Collection U. S. National Museum.

2*c*. Interior of ventral valve from Troy, New York. The differences between 2*b* and 2*c* are largely owing to the condition of preservation of the shells. Notation same as 2*b*. Collection U. S. National Museum.

2*d*. Interior of dorsal valve from Bic Harbor. Better specimens will be required in order to make out the details of structure. Collection U. S. National Museum.

2*e*. Exterior of dorsal valve from Troy, New York. Collection U. S. National Museum.

All figures of 2, enlarged.

3. Interior of dorsal valve. Compare with 1*c*, 1*d*. Notation same as figures 1*c*, 1*d*. Collection U. S. National Museum.

3*a*. Interior of ventral valve (?); 3 and 3*a* from L'Anse au Loup. Collection U. S. National Museum.

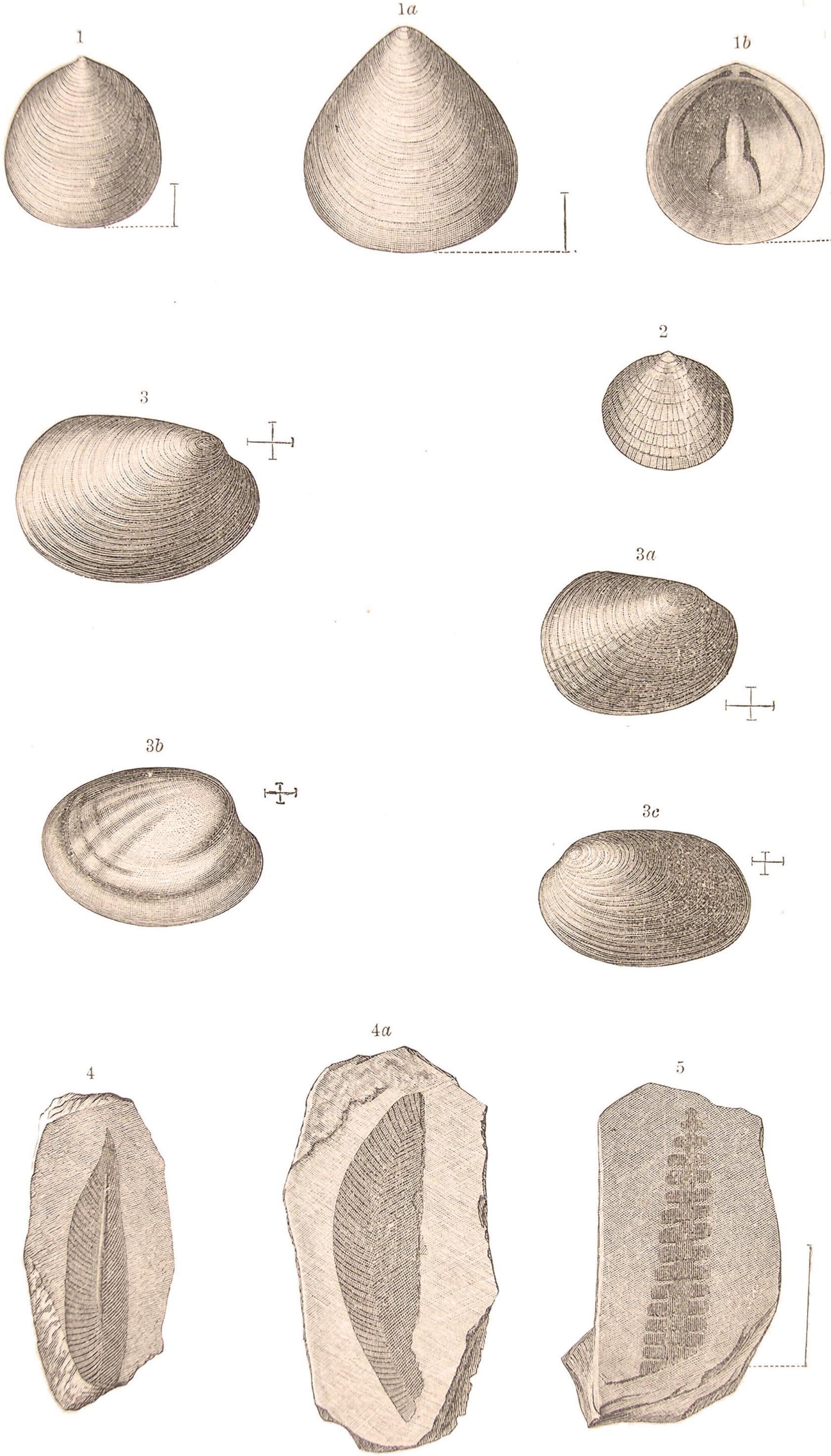

1
1a
1b
2
3
3a
3b
3c
4
4a
5

PLATE XI.

Page.

Fig. 1. OBOLELLA CHROMATICA 112

1. Dorsal valve from L'Anse au Loup, enlarged. Collection U. S. National Museum.

1*a*. Ventral valve from L'Anse au Loup, enlarged. Collection U. S. National Museum.

1*b*. Interior of dorsal valve, enlarged. Scars the same as in *O. crassa*. Collection U. S. National Museum.

Fig. 2. OBOLELLA NITIDA 118

2. Dorsal? valve, enlarged to 5 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

Fig. 3. FORDILLA TROYENSIS 125

3. Right valve, enlarged. Collection U. S. National Museum.

3*a*. A shorter right valve than that of 3, enlarged. Collection U. S. National Museum.

3*b*. Cast of the interior of the right valve, enlarged. Collection U. S. National Museum.

3*c*. Left valve, enlarged. Collection U. S. National Museum.

Fig. 4. DIPLOGRAPTUS ? SIMPLEX 92

4, 4*a*. Two fronds, natural size, from the fine-grained argillites of Parker's quarry. Collection U. S. National Museum.

Fig. 5. CLIMACOGRAPTUS ?? EMMONSI 93

5. The only specimen known to me. Collection of Mr. E. Hurlburt.

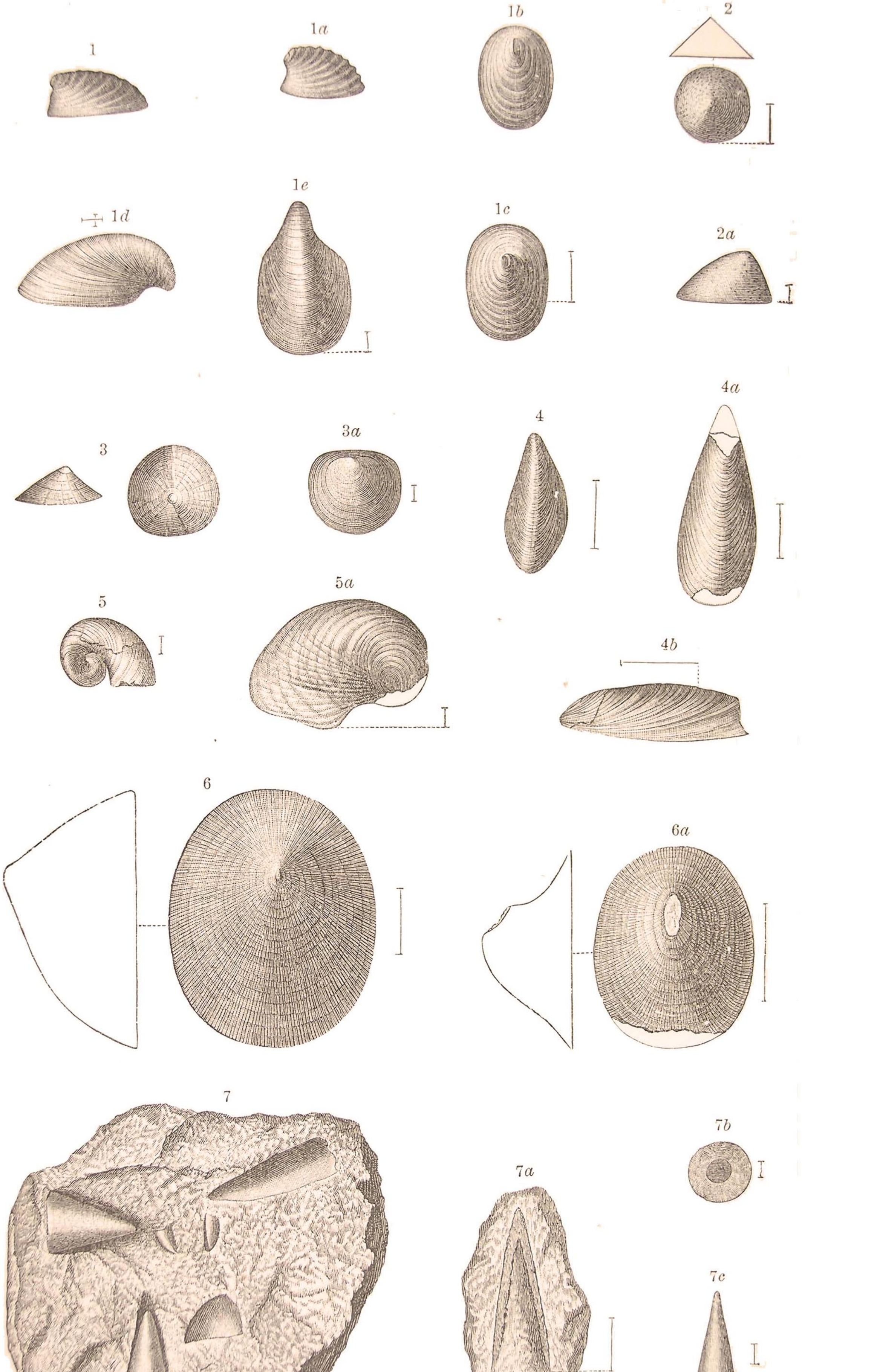

1
1a
1b
2
1d
1e
1c
2a
3
3a
4
4a
5
5a
4b
6
6a
7
7a
7b
7c

PLATE XII.

Page.

Fig 1. STENOTHECA RUGOSA 128

1. Lateral view of a medium-sized specimen. Collection U. S. National Museum.

1a. Lateral view of a more elevated and coarsely annulated specimen than 1. Collection U. S. National Museum.

1b, 1c. Summit views of two specimens, to show eccentricity of apex. Collection U. S. National Museum.

1d, 1e. Side and summit views of a very small shell. Collection U. S. National Museum.

All the specimens figured are from Troy, New York.

Fig. 2. SCENELLA ? VARIANS 127

2. Summit and lateral views of specimen with concentric apex. Collection U. S. National Museum.

2a. Lateral view of specimen with eccentric apex. Collection U. S. National Museum.

Fig. 3. SCENELLA RETUSA 126

3. Summit and lateral views of the type specimen; enlarged 3 diameters. (Drawing by S. W. Ford.) Collection S. W. Ford.

3a. Summit view of a specimen from Troy, New York, doubtfully referred to the species. Collection U. S. National Museum.

Fig. 4. STENOTHECA ELONGATA 129

4. Summit view of specimen from L'Anse au Loup. Collection U. S. National Museum.

4a, 4b. Summit and lateral views of specimen from the Eureka District, Nevada. Collection U. S. National Museum.

Fig. 5. PLATYCERAS PRIMÆVUM 130

5. View of cast, right side. Collection U. S. National Museum.

5a. Left side, enlarged to show characters of the outer surface of the shell. Collection U. S. National Museum.

Fig. 6. SCENELLA RETICULATA 125

6, 6a. Enlarged figures of the two supposed type specimens from Topsail Head, Newfoundland. Collection Geological Survey of Canada.

Fig. 7. SALTERELLA PULCHELLA 144

7, 7a. Casts of specimens in the "Red Sandrock," east of Highgate Springs, Vermont. Collection U. S. National Museum.

7b, 7c. Specimens from the "Winooski" marble, near Swanton, Vermont. These probably belong to a different species. Collection U. S. National Museum.

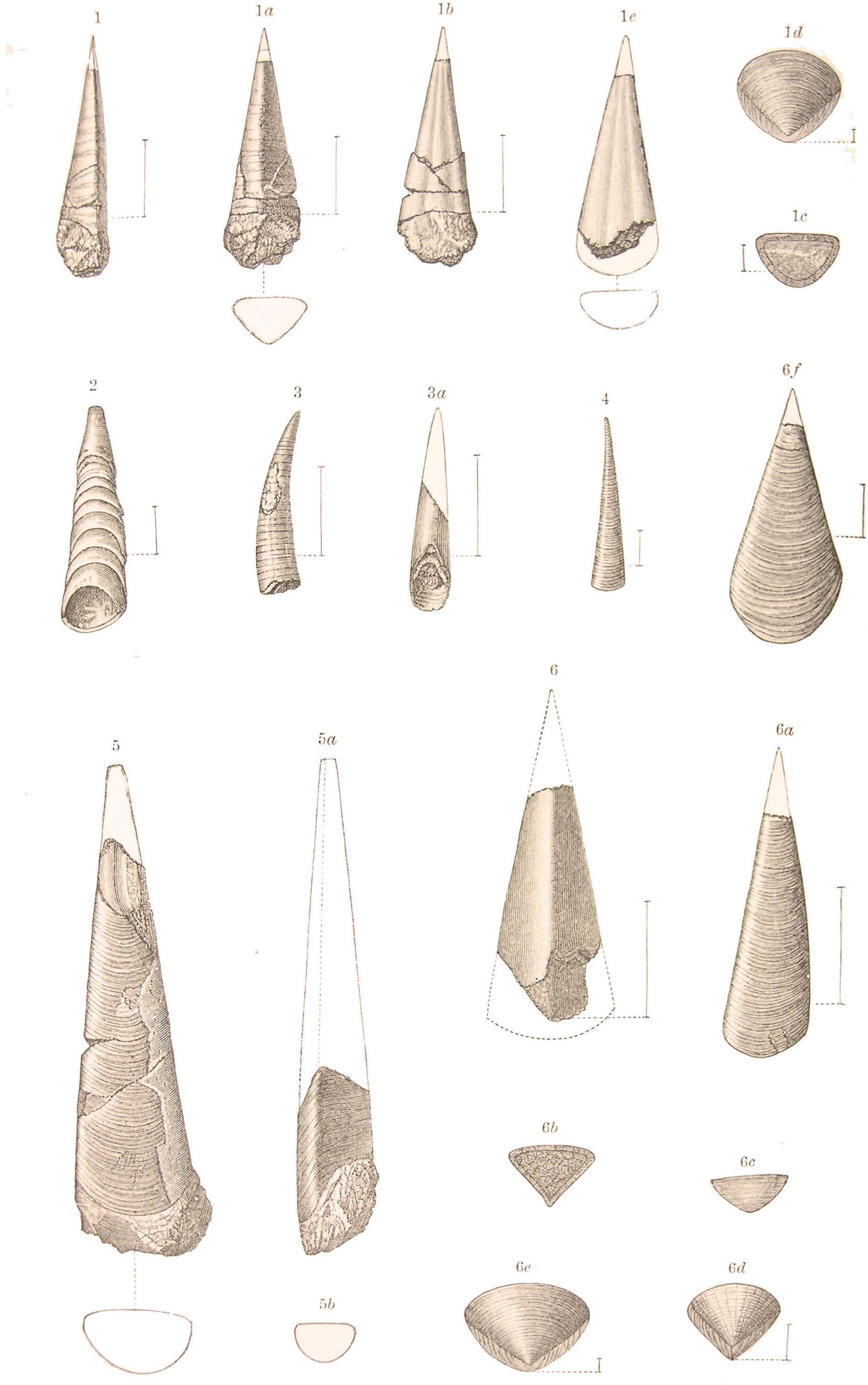

1
1a
1b
1e
1d
1c
2
3
3a
4
6f
6
5
5a
6a
6b
6c
6e
6d
5b

PLATE XIII.

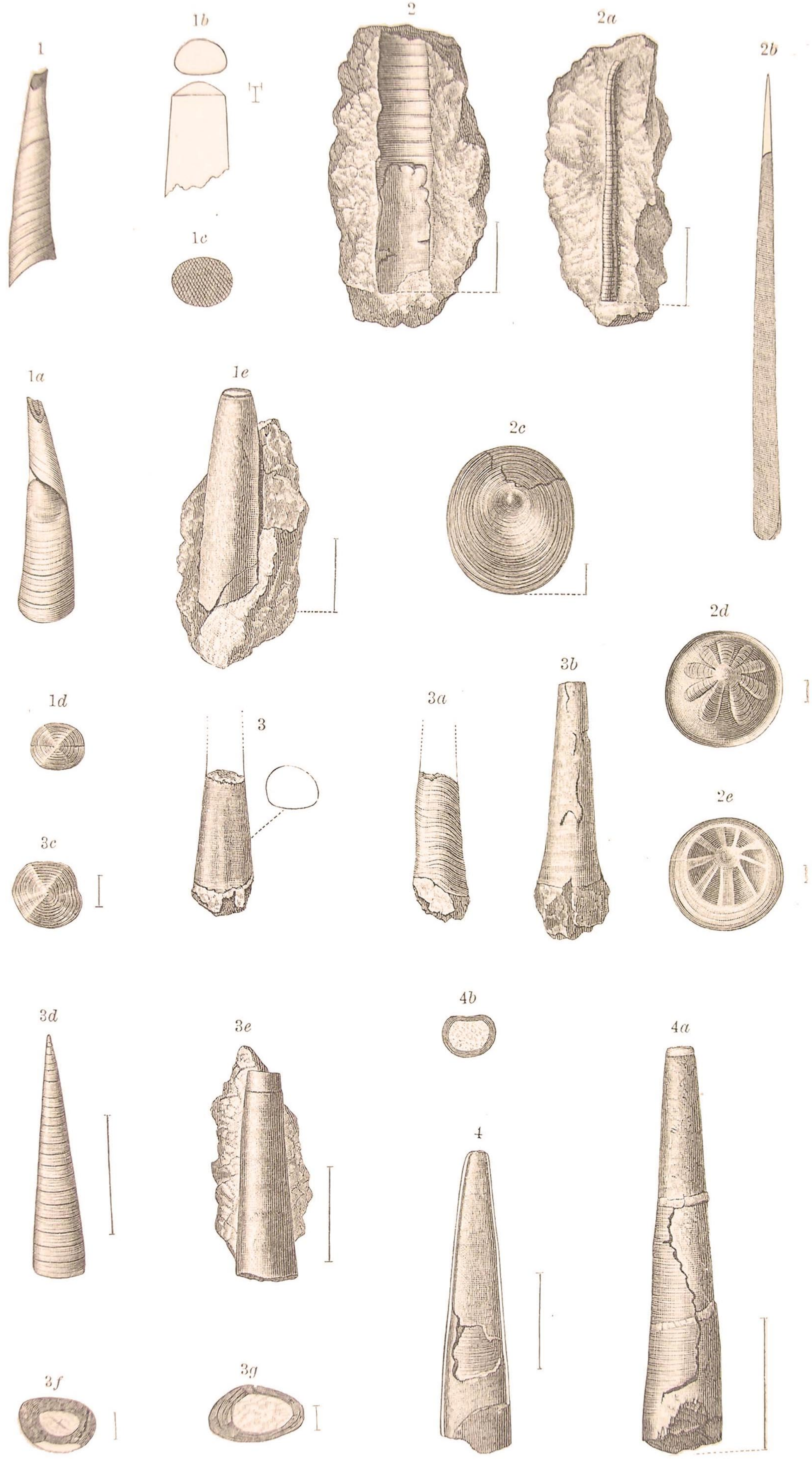

1
1b
1c
2
2a
2b
1a
1e
2c
2d
1d
3
3a
3b
3c
2e
3d
3e
4b
4a
4
3f
3g

PLATE XIV.

Page.

Fig. 1. HYOLITHES IMPAR 139

1, 1*a*. Lateral and ventral views of the type specimen. (Drawing by S. W. Ford.) Collection S. W. Ford.

1*b*. Outline of end of tube at point of septum, and transverse section of same, enlarged. Collection U. S. National Museum.

1*c*. Transverse section of 1.

1*d*. Operculum from Troy, New York. Collection U. S. National Museum.

1*e*. Cast of tube, showing constriction at the septum. Collection U. S. National Museum.

Fig. 2. HYOLITHELLUS MICANS 142

2. A fragment of the shell remaining in a natural mold, enlarged to show the annulations. Collection U. S. National Museum.

2*a*. Enlargement of the terminal portion of a tube. Collection U. S. National Museum.

2*b*. A crushed specimen in shale. Presented by S. W. Ford. Collection U. S. National Museum.

2*c*. Exterior of operculum. Collection U. S. National Museum.

2*d*. Cast of the interior of an operculum. Collection U. S. National Museum.

2*e*. Interior of an operculum. Collection U. S. National Museum. All specimens from Troy, New York, except 2*b*, which was found one mile below Schodack Landing.

Fig. 3. HYOLITHES COMMUNIS 136

3, 3*a*. Dorsal and side views of specimen from Bic Harbor. Natural size. Collection U. S. National Museum.

3*b*. Another specimen from Bic Harbor. Collection U. S. National Museum.

3*c*. Operculum from Bic Harbor. Collection Geological Survey of Canada.

3*d*, 3*e*. Specimens from Troy, New York. Collection U. S. National Museum.

3*f*, 3*g*. Transverse sections to show irregularities of thickness of shell. Collection U. S. National Museum.

Fig. 4. HYOLITHES COMMUNIS var. EMMONSI 137

4. Dorsal view of specimen showing evidence of three layers of shell and a septum. Collection U. S. National Museum.

4*a*. Ventral view of a specimen, showing the constriction at the point of decollation of the apex. Collection U. S. National Museum.

PHYLLOPODA.

PLATE XV.

1. Figure given in Bulletin 10, U. S. Geological Survey, plate x. Description on page 50. Reproduced here in order to show the Middle Cambrian fauna, as known to me, in one series of plates. Collection U. S. National Museum.

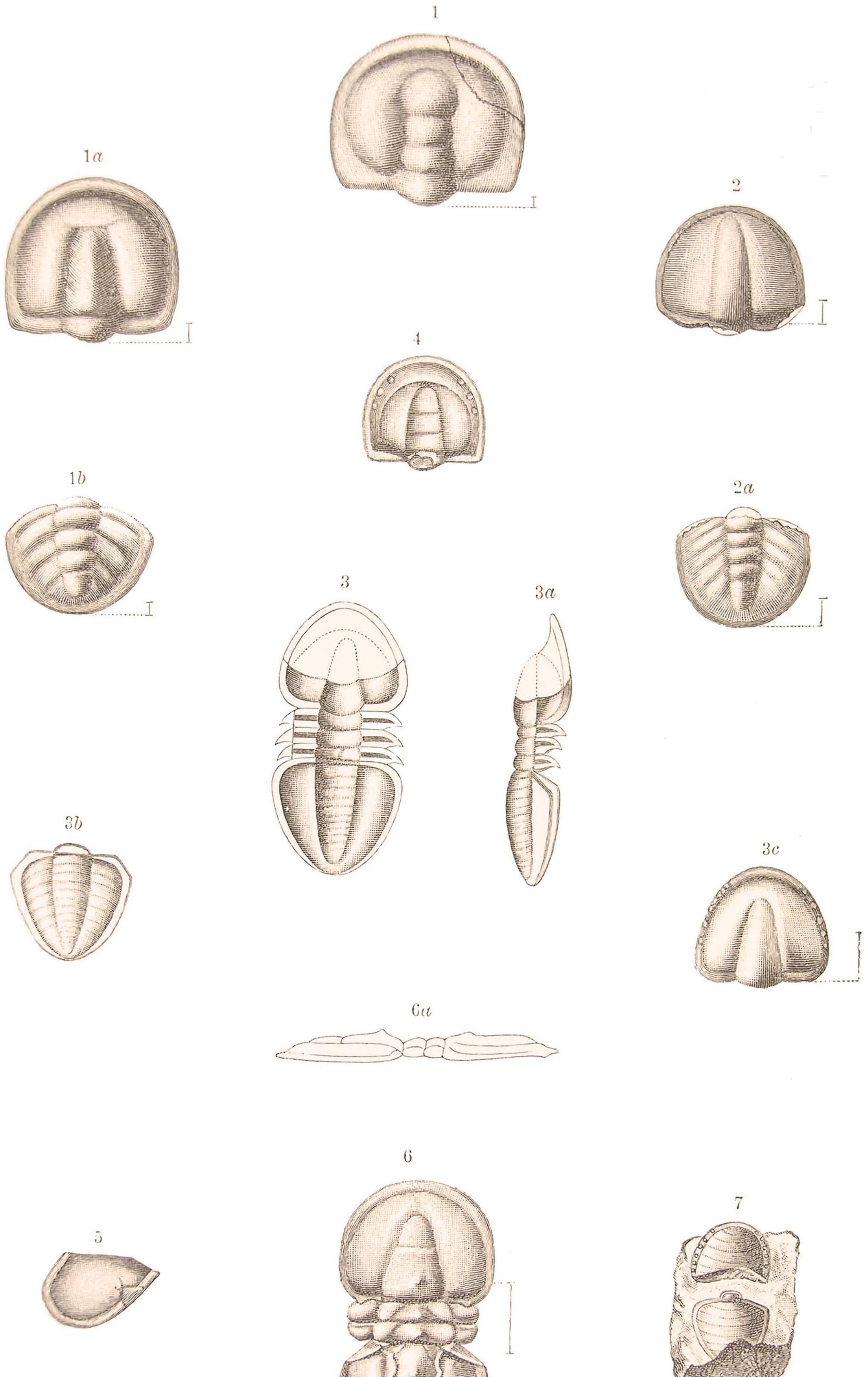
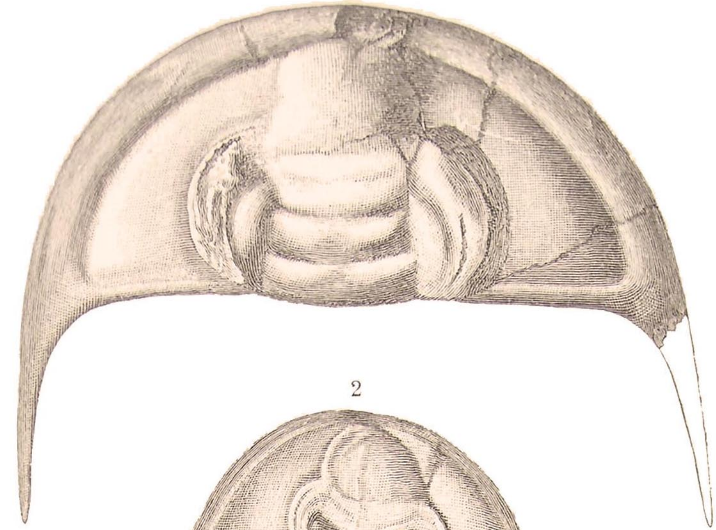
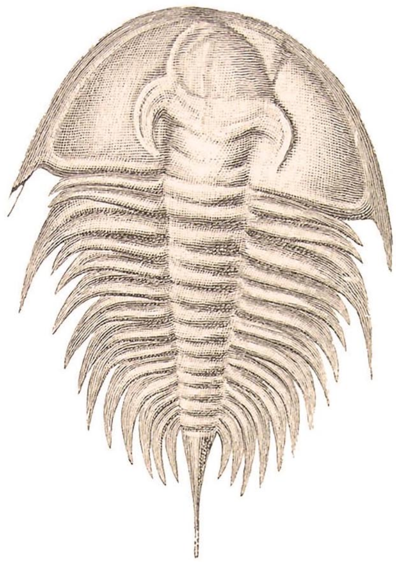

1
1a
2
4
1b
2a
3
3a
3b
3c
6a
6
5
7

PLATE XVI.

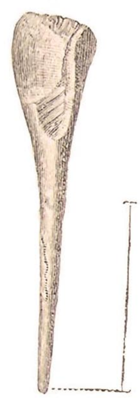
1



2

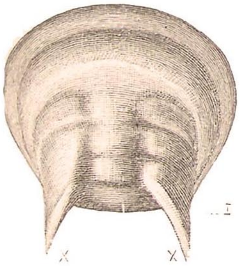


3

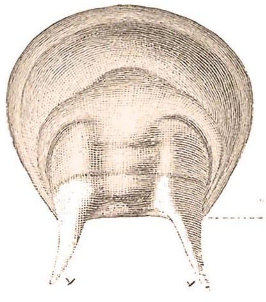


4

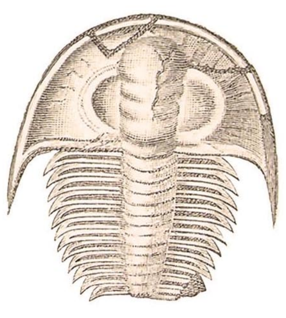
5



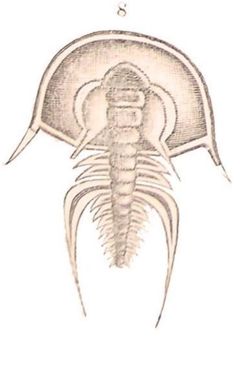
6



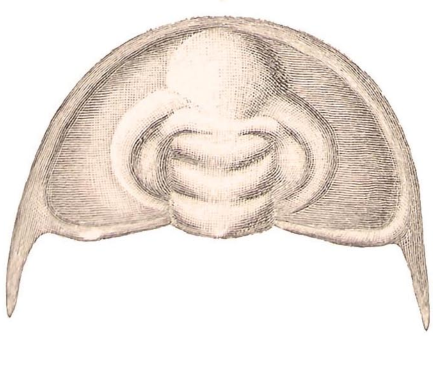
7



8



9



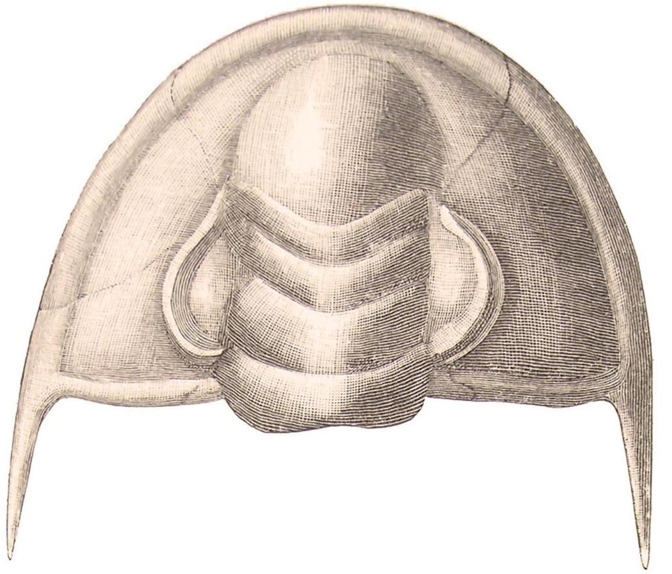
10

PLATE XVII.

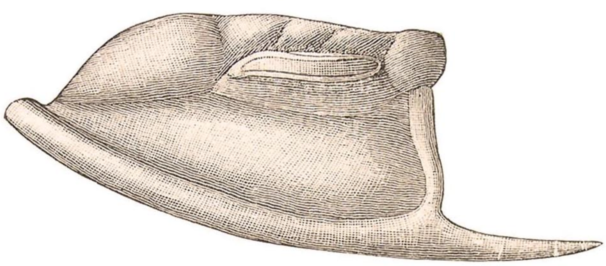
1. Head with an unusually broad border, from Swanton, Vermont. Collection U. S. National Museum.
2. Entire specimen from fine argillaceous shales at Parker's quarry. Collection U. S. National Museum.
4. Telson or pygidium found in the Winooski marble series, west of Parker's quarry. Collection U. S. National Museum.
9. A very perfect head, preserving the natural convexity, from the decomposed magnesian limestone east of Swanton. As portions of the specimen were broken away other specimens were used to aid the draughtsman in representing an entire head. Collection U. S. National Museum.

3. Telson associated with fragments of this species at Troy, New York. Collection U. S. National Museum.
5. The youngest stage of development yet observed by the writer. Length, four-fifths of one millimeter. Collection U. S. National Museum.
6. A slightly larger specimen, 1.75^{mm} in length. Collection U. S. National Museum.
7. Adult form. (After Ford.) Collection S. W. Ford.
8. Young form. (After Ford.) Collection S. W. Ford.
10. Hypostoma associated with, and supposed to belong to, this species. Collection U. S. National Museum.

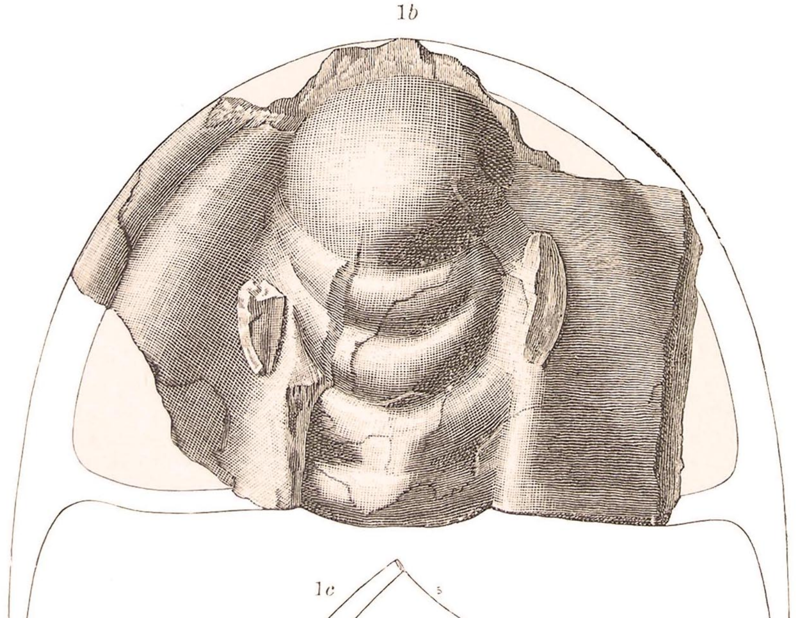
1



1*a*



1*b*



1*c*

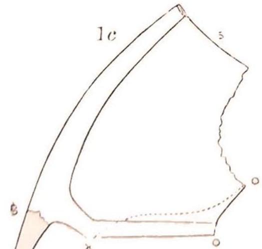


PLATE XVIII.

Page.

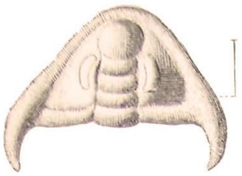
Fig. 1. OLENELLUS GILBERTI 170

1, 1*a*. Top and lateral views of type specimen from Pioche, Nevada. Collection U. S. National Museum.

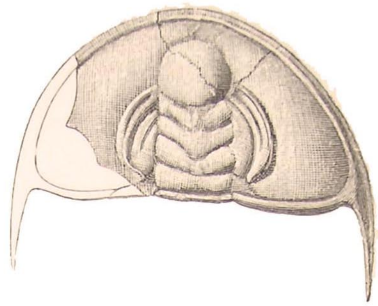
1*b*. Fragment of a large head from the Eureka mining district, Nevada. Collection U. S. National Museum.

1*c*. Free cheek found detached from fixed cheek. The direction of the suture in front of the eye is well defined; its direction, posteriorly, may be along the line of fracture, *oo;* but it is impossible to satisfactorily determine it; if as in fig. 1*i* of pl. xx, it would follow the dotted line *o, x.* Collection U. S. National Museum.

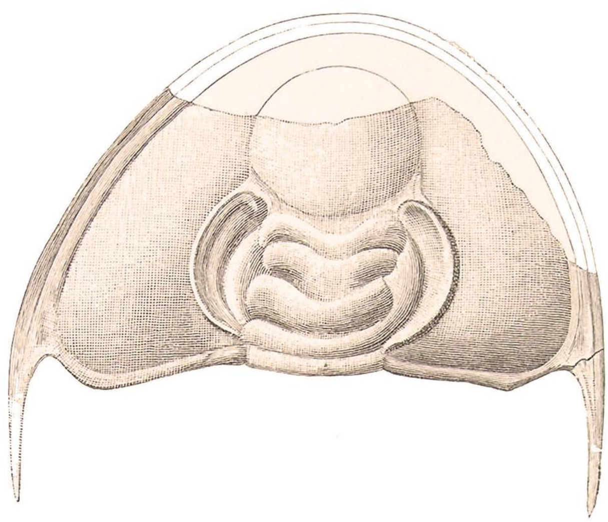
1



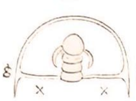
2



2a



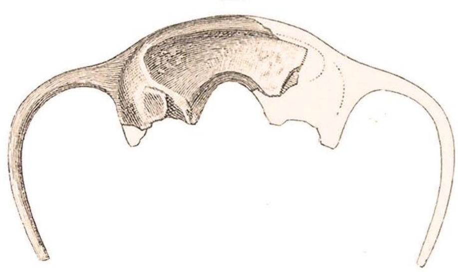
2c



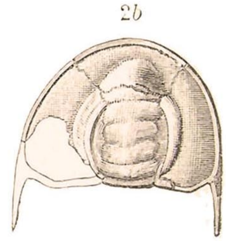
2e

2f

2d

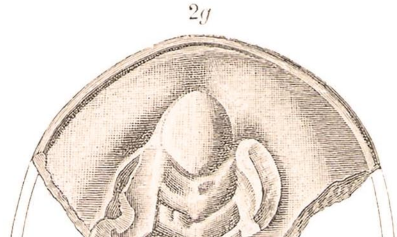


2b

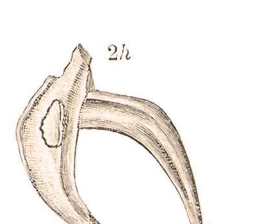


2i

2g



2h



2k

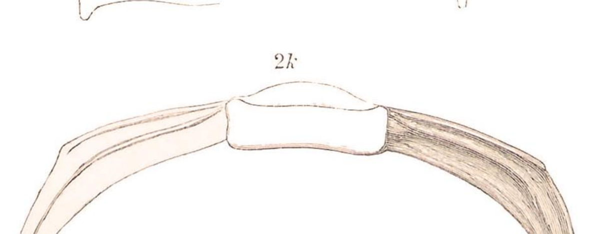


PLATE XIX.

Page.

Fig. 1. OLENELLUS IDDINGSI 170

1. View of the type specimen, enlarged to 2 diameters. Collection U. S. National Museum.

Fig. 2. OLENELLUS GILBERTI 170

2, *2a*, *2b*, *2k*. Figures of the type specimens illustrated by Dr. White, from Pioche, Nevada.

2c, *2g*, *2h*. Specimens from the Eureka district, Nevada.

2d. A portion of a head referred to this species, showing the same carrying forward of the genal angles that is shown in specimens from the Eureka district. Groom district, Nevada.

2e. A worn specimen of a young individual of this species, or *Olenellus Iddingsi*. Groom district, Nevada.

2f. Hypostoma associated with this species in the Eureka district, Nevada.

2i. Prolonged pleura of third (?) segment of this species. Associated with *2f*.

All originals of 2 are in the collection of the U. S. National Museum.

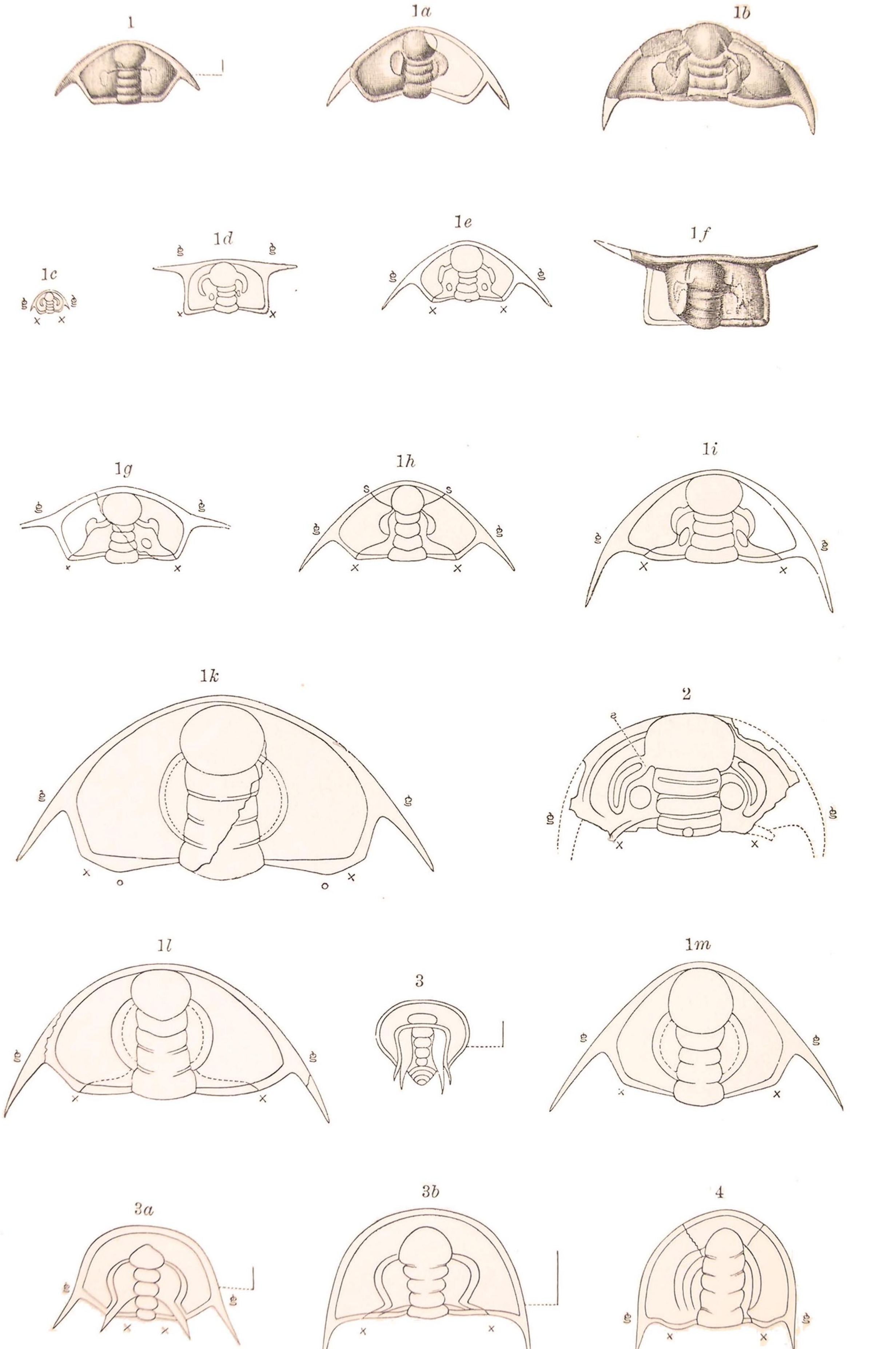

1
1a
1b
1c
1d
1e
1f
1g
1h
1i
1k
2
1l
3
1m
3a
3b
4

PLATE XX.

Page.

Fig. 1. OLENELLUS GILBERTI 170

1, 1*c*. Smallest specimen of the head in the collection; eyes distant from the glabella.

1*a*. A larger specimen than 1, but with the genal angles carried forward, while the eyes are close to the glabella.

1*b*. Genal angles normal, but eyes united to the glabella by an ocular ridge.

1*d*. Head showing the anterior position of the genal spines, *gg*, and the angles of the posterior margin, *xx*, extravagantly developed. The difference in the length of the ocular ridges of the right and left sides is also very marked. Natural size.

1*e*. The smallest individual in which the posterior course of the facial suture was observed. The outline of the head is much like that of fig. 1. Natural size.

1*f*. A specimen from Southern Nevada, with the genal spines still further advanced than those of 1*d*.

1*g*. Form intermediate in contour of head between figs. 1*d* and 1*e*. *gg*, Genal angles and spines; *xx*, angles of the posterior margin. Natural size.

1*h*. The eyes in this specimen are no longer pedunculated or united to the glabella by an ocular ridge, and the genal angles are more posterior. The course of the facial suture, in front of the eye, is also seen for the first time. Natural size.

1*i*. Example in which the genal angles are in the same position as in the adult individual in species of this genus. The eyes are more embryonic in character than in the preceding example. Natural size.

1*k*. Broader and more common form, showing the same peculiarities as fig. 1*m*. Natural size.

1*l*. The right and left sides are irregularly developed, the genal spine on the left side being more anterior in position. The course of the facial suture is traced in accordance with its position, as observed in fig. 6. Natural size.

1*m*. Narrow form, with the eyes of the adult type, and having the genal angles carried forward, as in the younger individuals, 1*c*, 1*e*, 1*h*. Natural size.

The originals of the above are in the collection of the U. S. National Museum.

Fig. 2. PARADOXIDES KJERULFI 178

2. Outline of head showing the position of the genal angles and angles of the posterior margin, *xx*, with the interocular spine; also, the ocular ridge (*a*) uniting the glabella and eyes. (After Linnarsson.)

Fig. 3. OLENELLUS ASAPHOIDES 168

3. Embryonic form showing the circular outline, the genal spines in close proximity to the facial suture, and the interocular spines, enlarged 3½ diameters. (After Ford.) Collection S. W. Ford.

3*a*. Another phase of the development of this species, succeeding with probably intermediate forms, fig. 3. The position of the genal spines, *gg*, and the sutures cutting the posterior margin at the angles, *xx*, is comparable to the same in fig. 1*e*, enlarged to 5 diameters. (After Ford.) Collection S. W. Ford. (See plate xvii.)

3*b*. Normal adult type of the head of this species, enlarged to 2 diameters. (After Ford.) Collection S. W. Ford.

Fig. 4. OLENELLUS GILBERTI 170

4. Narrow form of head that shows the angles in the posterior margin, *xx*, slightly developed. Natural size. (After White.) Collection U. S. National Museum.

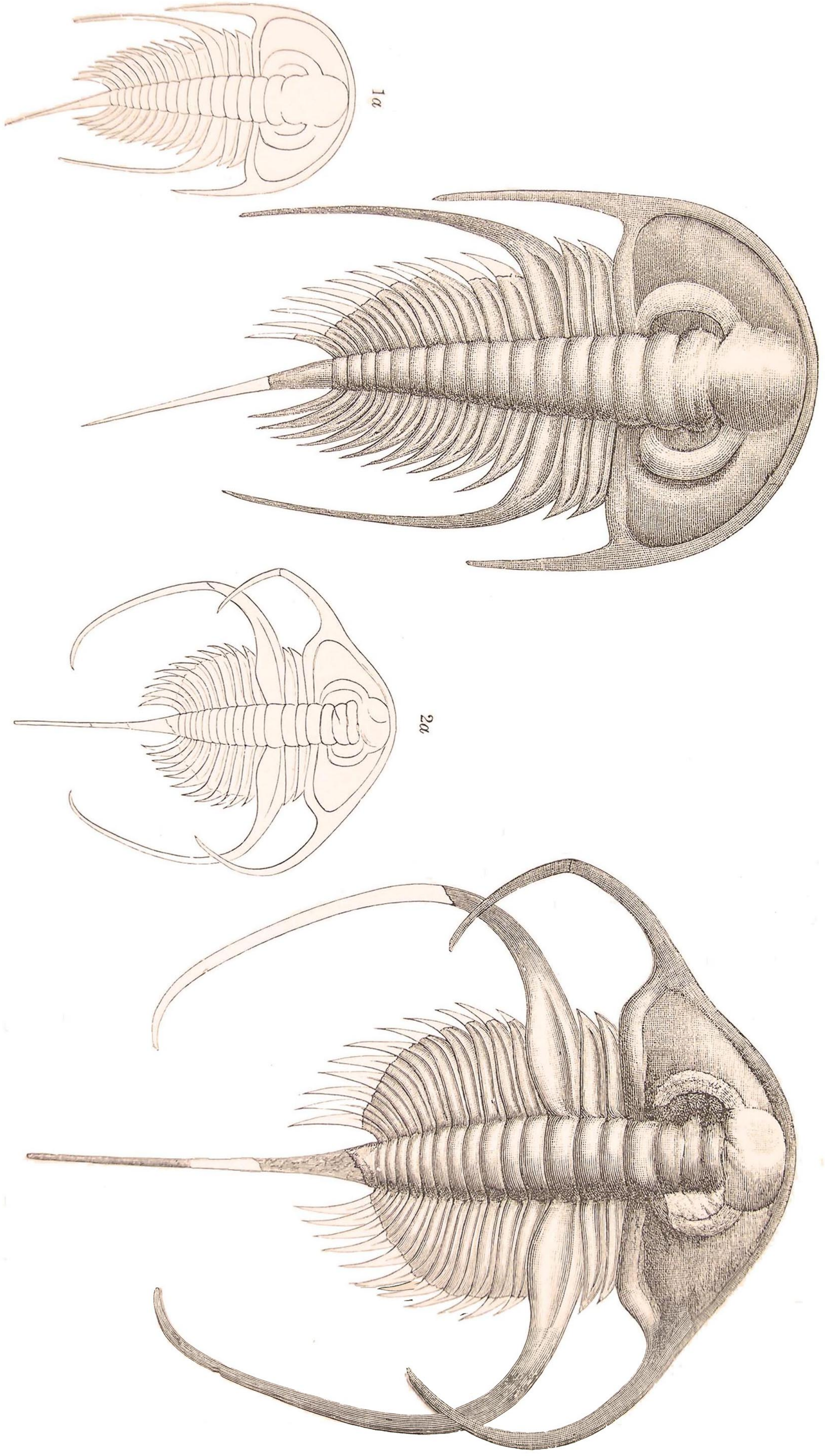

1a
1
2a
2

PLATE XXI.

Page.

Figs. 1 and 2. OLENELLUS GILBERTI 170

1. Normal form of the species, except the unusual prolongation of the third segment. Collection U. S. National Museum.

1*a*. Outline of the specimen from which fig. 1 was enlarged. Natural size.

2. Specimen broadened by longitudinal compression. The head shows features observed in the series of heads figured on plate xx. The long, slender extremities of the genal spines and the terminations of the third thoracic segments are not often observed. Collection U. S. National Museum.

2*a*. Outlined figure from which fig. 1 was enlarged. Natural size.

1

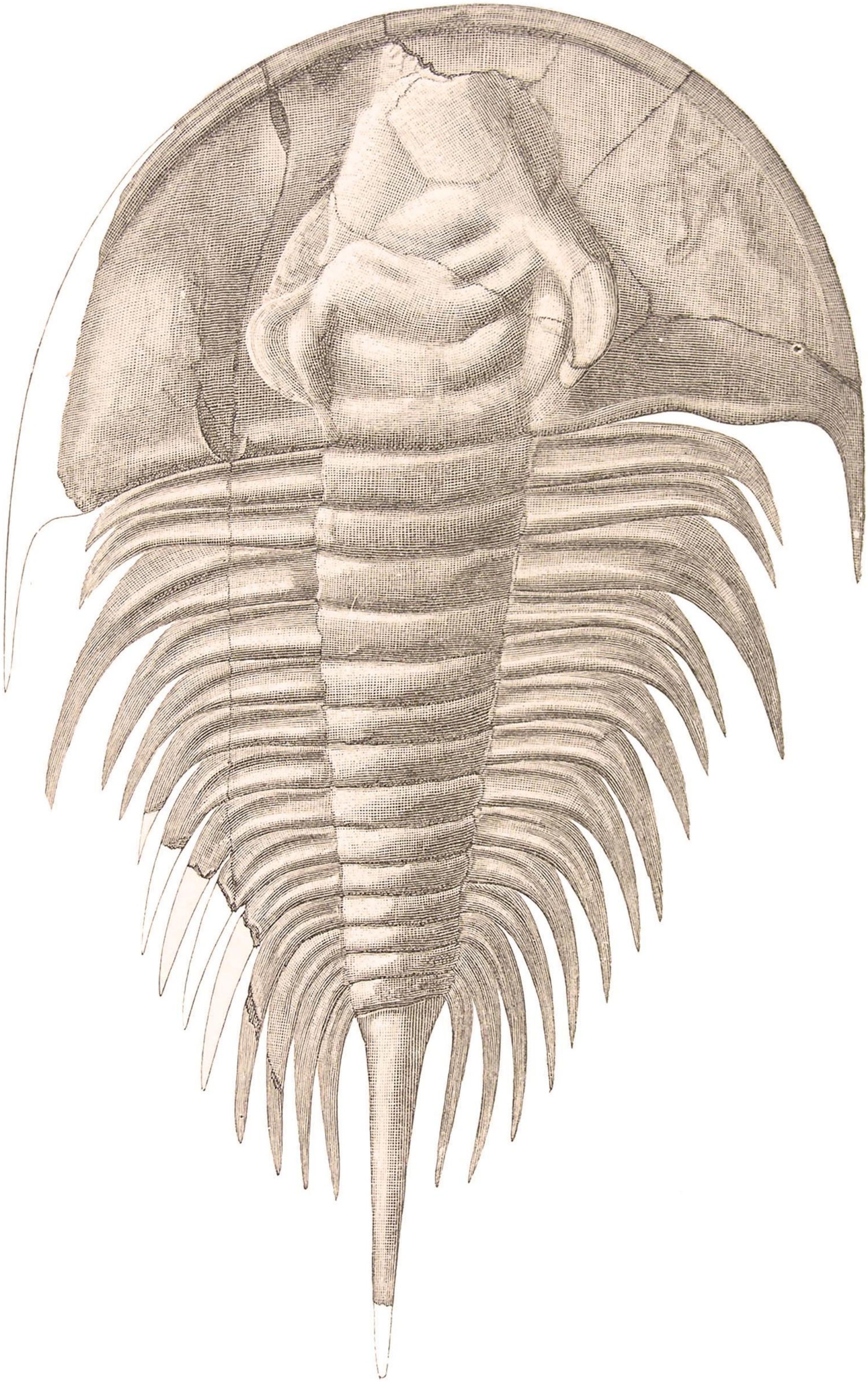


PLATE XXII.

1. A nearly entire specimen from Parker's quarry. **Natural size.** Collection U. S. National Museum.

1

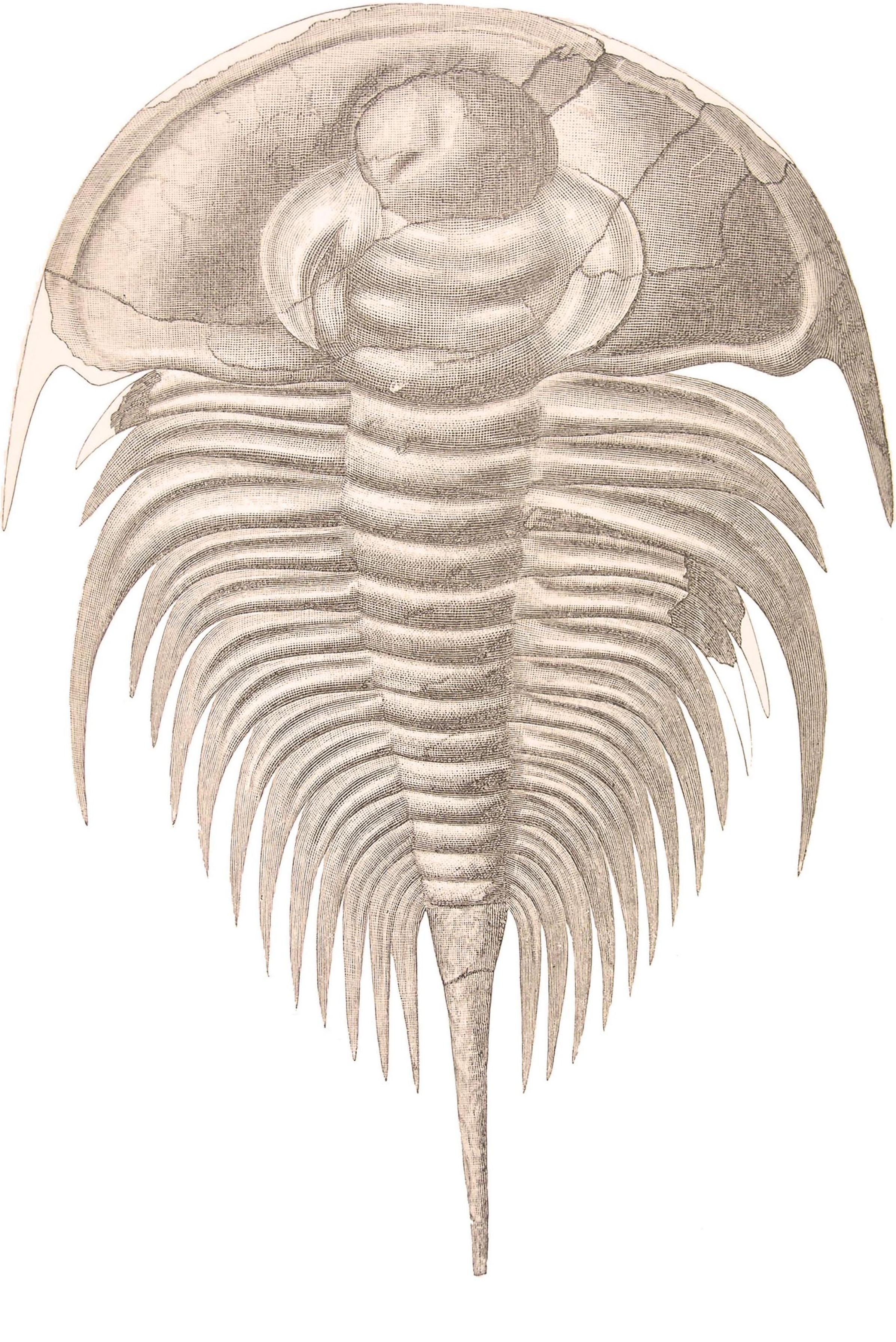
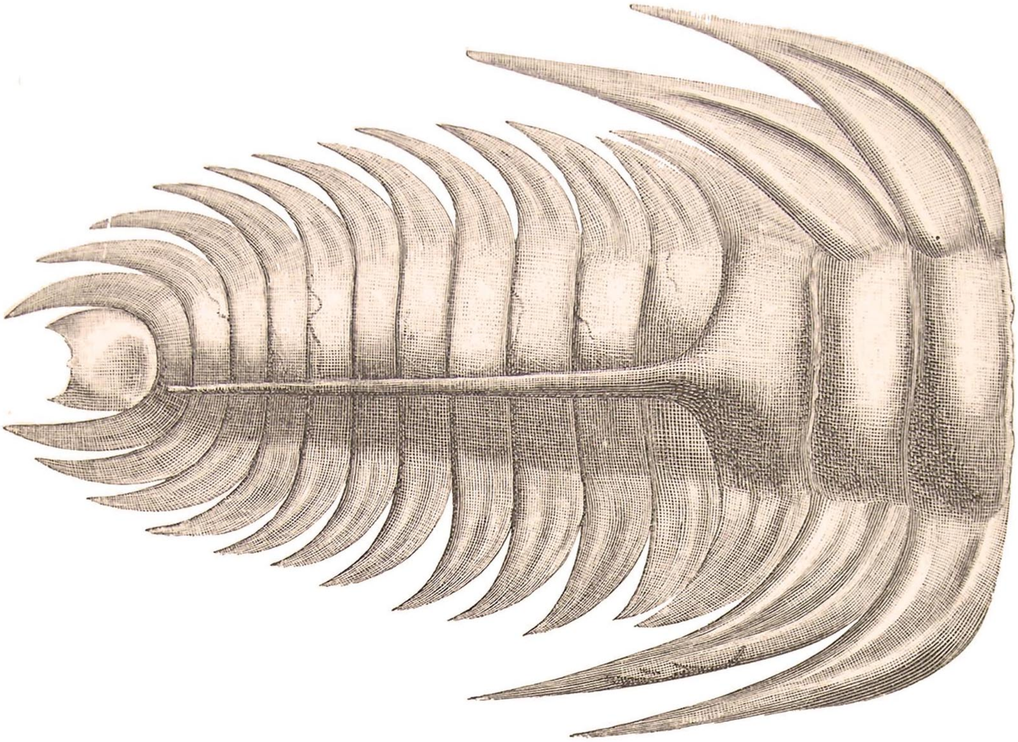
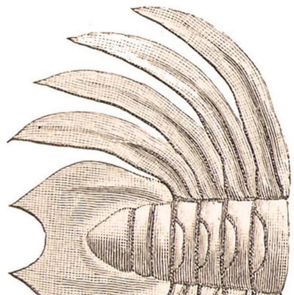


PLATE XXIII.

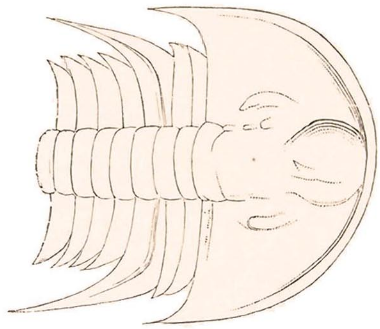
1. A specimen showing an unusual prolongation of the third segment. Collection U. S. National Museum.



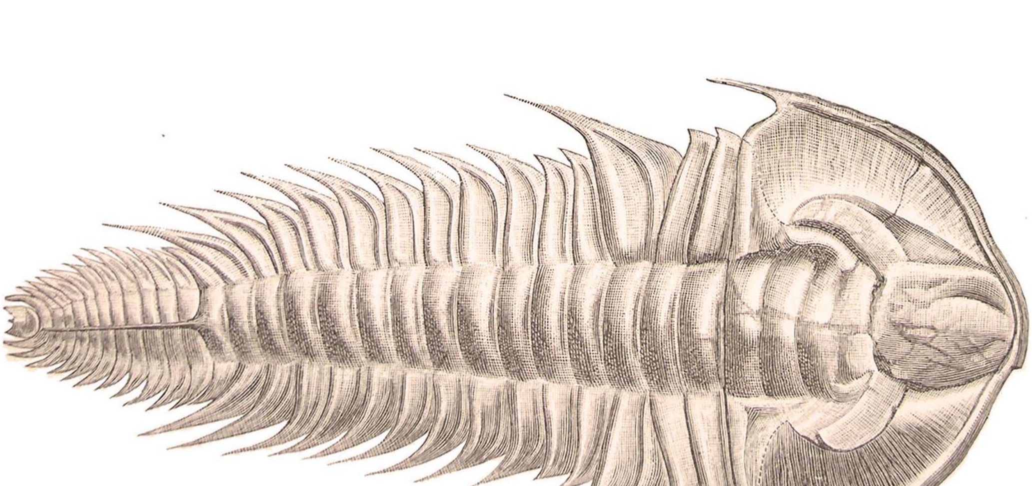
1b



2



1



1a

PLATE XXIV.

		Page.
Fig. 1.	MESONACIS VERMONTANA	158

1. Copy of the original figure of the type specimen of the species. Collection American Museum of Natural History, New York City.

1*a*. A very perfect specimen from the collection of Mr. E. Hurlburt. The matrix is in the U. S. National Museum collection.

1*b*. Enlargement of the posterior portion of 1*a*. The spine projecting from the fifteenth segment is flattened down on the thorax more than is shown in the figure.

Fig. 2.	PARADOXIDES RUGULOSUS	162

2. Pygidium and four posterior thoracic segments, enlarged after Barrande (Syst. Sil. Bohême, vol. i, pl. ix, fig. 31, 1852), which is introduced for comparison with fig. 1*b*.

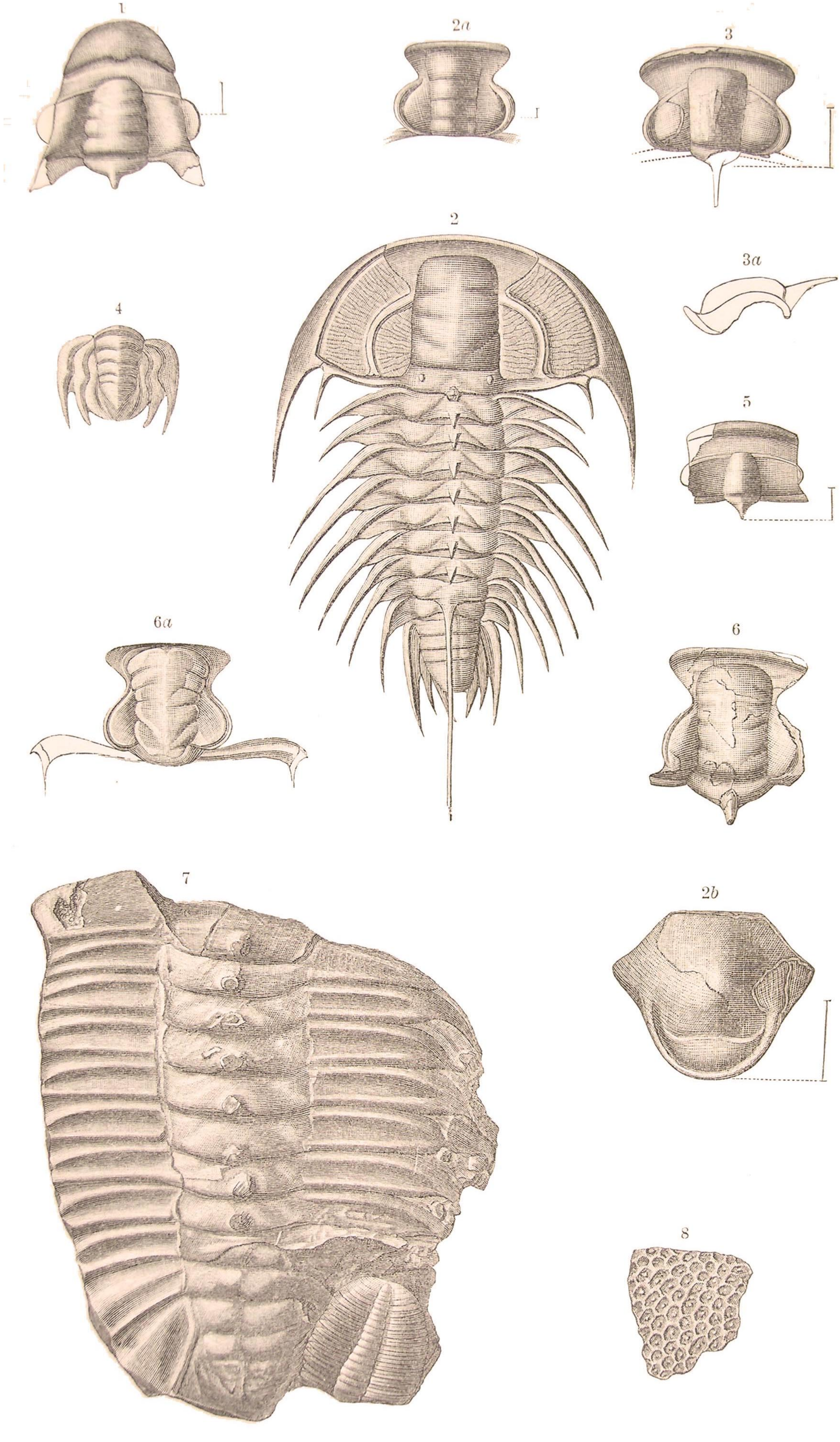
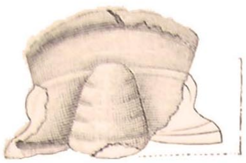

1
2a
3
2
3a
4
5
6a
6
7
2b
8

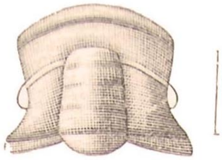
PLATE XXV.

	Page.
Fig. 1. ANOMOCARE ? PARVUM	209
1. View of type specimen, enlarged. Collection U. S. National Museum.	
Fig. 2. OLENOIDES TYPICALIS	183
2. View of type specimen, enlarged to 2 diameters. The free cheeks are displaced in the original and are restored from another specimen. Collection U. S. National Museum.	
2*a*. A very small head, greatly enlarged. The differences, as compared with fig. 2, are in the form of the glabella and glabellar furrows. Collection U. S. National Museum.	
Fig. 3. OLENOIDES LEVIS	187
3. View of the type specimen. Collection U. S. National Museum.	
3*a*. Lateral view of 3.	
Fig. 4. OLENOIDES ? FLAGRICAUDUS	185
4. View of the type specimen from Pioche, Nevada. Collection U. S. National Museum.	
Fig. 5. PTYCHOPARIA HOUSENSIS	201
5. View of the type specimen from Antelope Springs, Utah. Collection U. S. National Museum.	
Fig. 6. OLENOIDES SPINOSUS	184
6. View of type specimen from the Eureka district, Nevada. Natural size. Collection U. S. National Museum.	
6*a*. Head of this or a closely allied species from Pioche, Nevada. Preserved in an arenaceous shale. Collection U. S. National Museum.	
Fig. 7. OLENOIDES NEVADENSIS	181
7. View of the type specimen of the genus and species from Antelope Springs, Utah. Collection U. S. National Museum.	
Fig. 8. OLENELLUS ASAPHOIDES	168
8. Enlargement of a bit of the shell of the free cheek. From Troy, New York. Collection U. S. National Museum. (See plate xvii.)	
Fig. 9. ASAPHISCUS WHEELERI	220
9. Hypostoma, enlarged. (See plate xxxi, fig. 3.) Collection U. S. National Museum.	

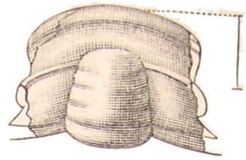
1



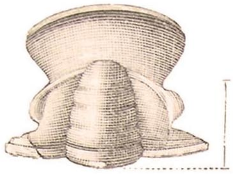
1a



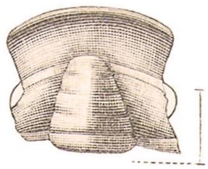
1b



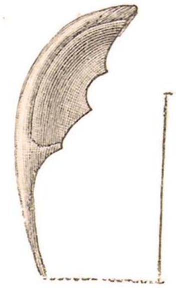
2



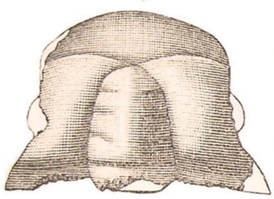
2a



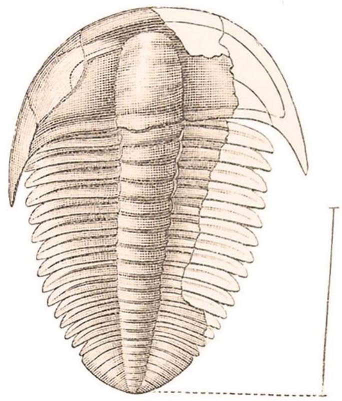
2b



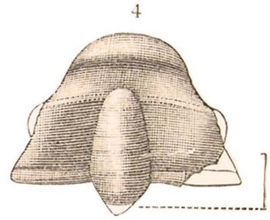
3



1c

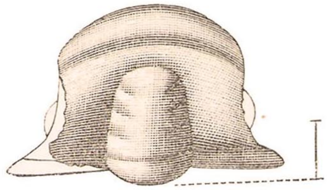


4

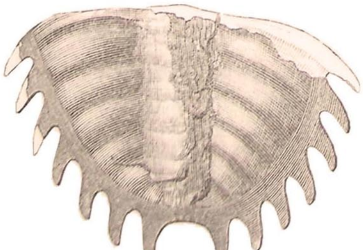


5

4a



5a



5b

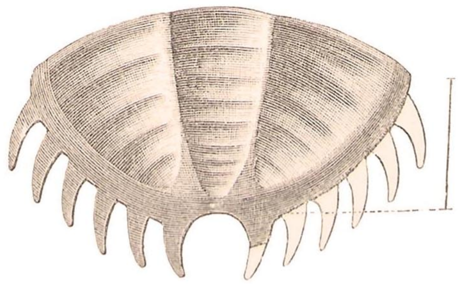
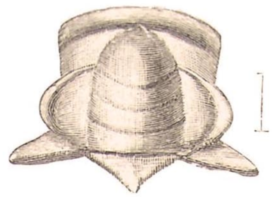


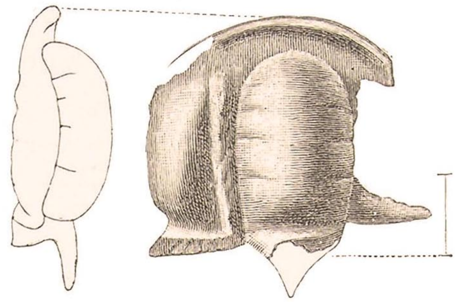
PLATE XXVI.

1

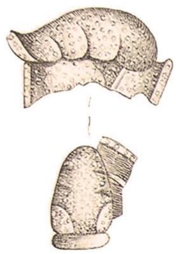
2



3

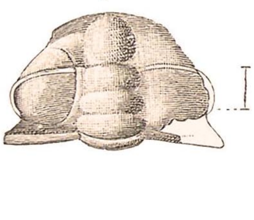


1*a*

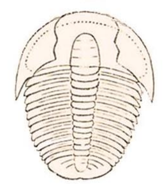


1*b*

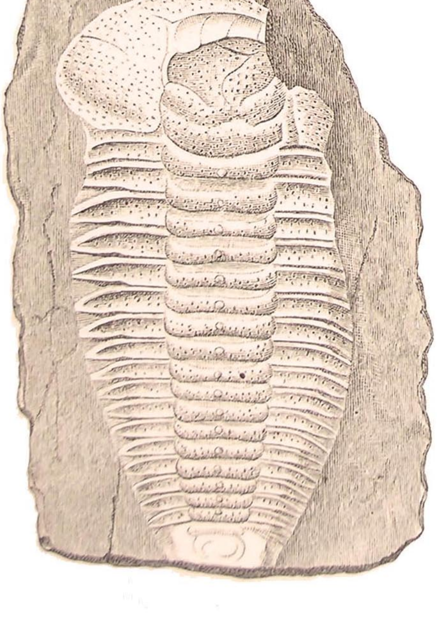
5



4*a*



1*c*



4

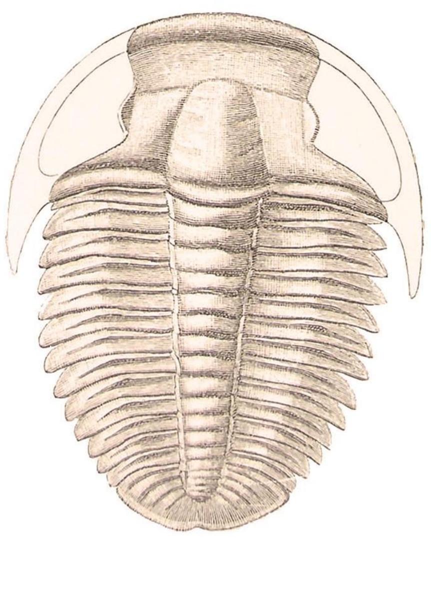
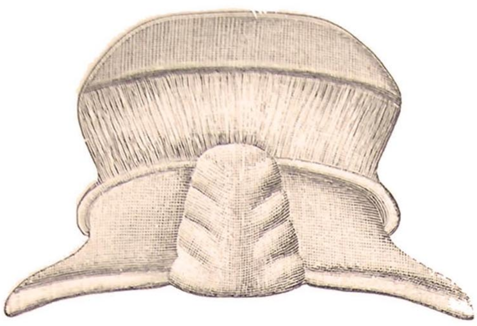
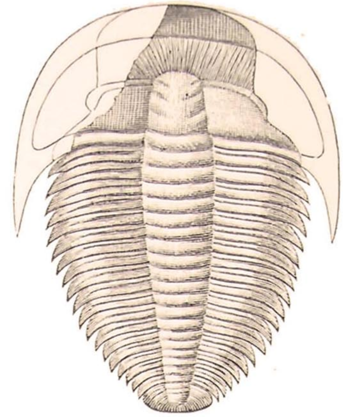


PLATE XXVII.

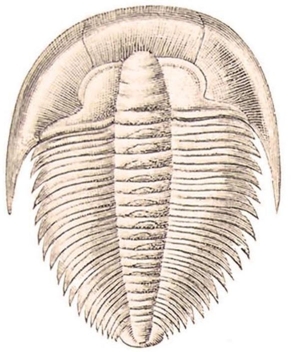
1



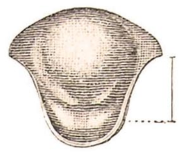
1a



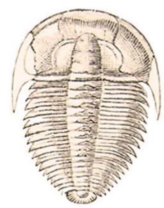
1b



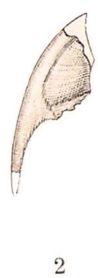
1e



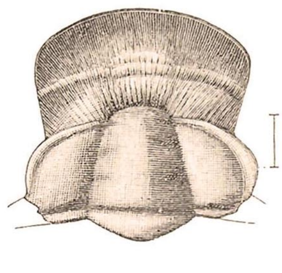
1c



3c

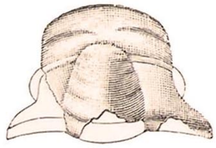


4



1d

2

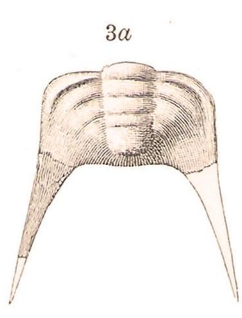


3

2b

2a

3a



3b

PLATE XXVIII.

Page.

Fig. 1. PTYCHOPARIA PIOCHENSIS 201

1. Largest head observed. The gradual narrowing of the frontal limb and margin is shown by figs. 1, 1*a*, 1*b*, 1*c*, 1*d*. Collection U. S. National Museum.

Specimens showing decrease in size: 1*a*, 19 thoracic segments; 1*b*, 19 thoracic segments; 1*c*, 17 thoracic segments; 1*d*, 16 segments preserved.) Collection U. S. National Museum.

1*e*. Hypostoma associated with this species. Collection U. S. National Museum.

See plate xxvi, figs. 2, 2*a*.

Fig. 2. CREPICEPHALUS AUGUSTA 208

2. Head, natural size. Collection U. S. National Museum.

2*a*. Pygidium associated with the heads of this species. Collection U. S. National Museum.

2*b*. A much smaller head showing variations from fig. 2. Collection U. S. National Museum.

Fig. 3. CREPICEPHALUS LILIANA 207

3. Large head, with granulose surface. Collection U. S. National Museum.

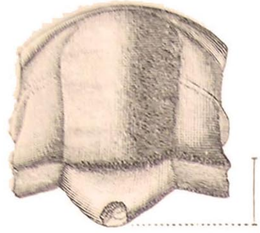
3*a*. Pygidium associated with 3 in the same fragment of rock. Collection U. S. National Museum.

3*b*. Cast of a smaller head. Collection U. S. National Museum.

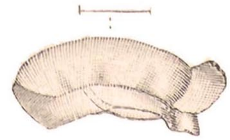
Fig. 4. PTYCHOPARIA SUBCORONATA 205

4. Figure of the type specimen figured by Hall & Whitfield, enlarged to 4 diameters. Collection U. S. National Museum.

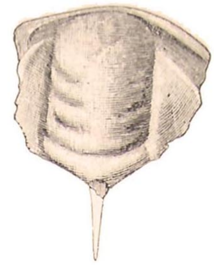
1



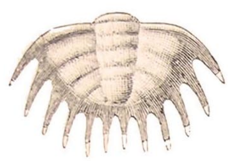
1a



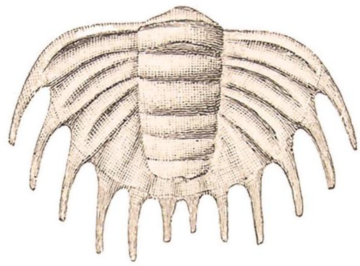
2



1b

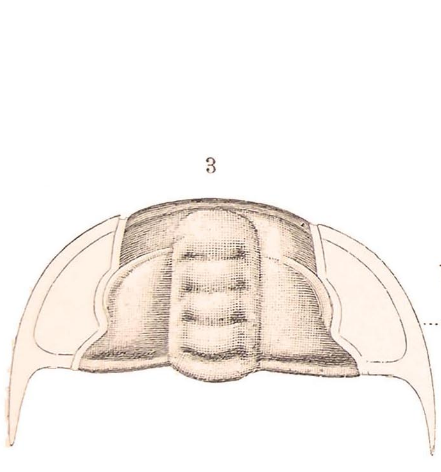


2a

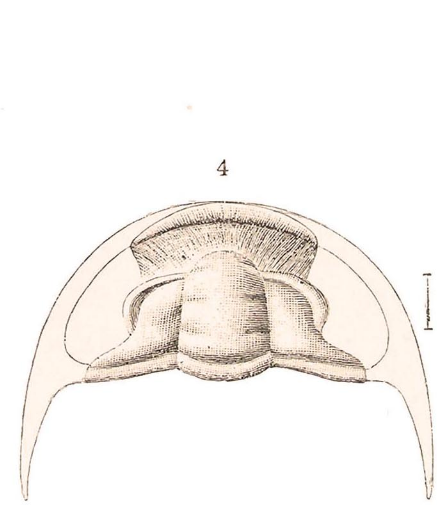


1c

3

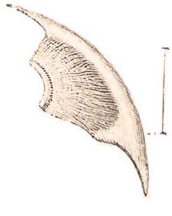


4



3a

4b



4a

PLATE XXIX.

Page.

Fig. 1. OLENOIDES QUADRICEPS 187

1. Original figure of *Dikellocephalus quadriceps* Hall & Whitfield, enlarged to 3 diameters. Collection U. S. National Museum.

1*a*. Side view of fig. 1.

1*b*, 1*c*. Top and side views of associated pygidium. Collection U. S. National Museum.

Fig. 2. OLENOIDES WAHSATCHENSIS 189

2. View of the type specimen of *Dikellocephalus Wahsatchensis* Hall & Whitfield. Collection U. S. National Museum.

2*a*. View of type specimen of *Dikellocephalus? gothicus* Hall & Whitfield. Collection U. S. National Museum.

Fig. 3. ORYCTOCEPHALUS PRIMUS 210

3. Head with the free cheeks in outline; the latter are raised up and appear broader than when attached to the central parts of the head. Collection U. S. National Museum.

3*a*. Pygidium that is associated in the same piece of rock with the head wherever the latter is found, enlarged to 4 diameters. Collection U. S. National Museum.

Fig. 4. PTYCHOPARIA QUADRANS 199

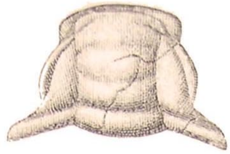
4. Central portions of the head with the free cheeks restored in outline. This figure varies from that given in vol. iv, Geol. Expl. Fortieth Par., pl. ii, fig. 11. It is drawn from a specimen marked as the type of the species.

4*a*. Associated pygidium.

4*b*. Associated free cheek.

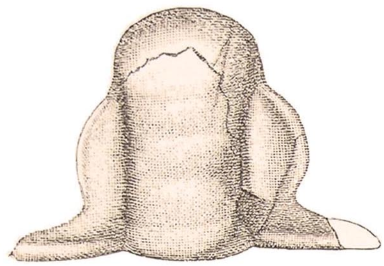
1

1a

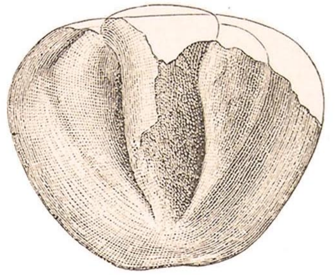


1b

1c

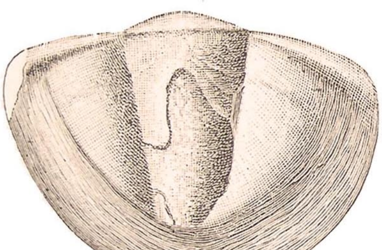


1e

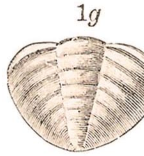


1f

1d



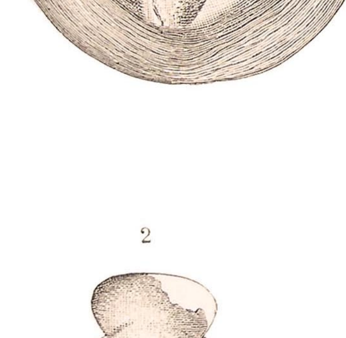
1g



1h

2a

2



1i

PLATE XXX.

Page.

Fig, 1. BATHYURISCUS PRODUCTUS 217

1, 1*a*. Narrow and broad forms of the head. Wasatch Mountains.

1*b*. Free cheek associated with 1*a*.

1*c*. Large head from the Highland Range.

1*d*. Pygidium associated with 1*c*.

1*e*. Type of *Ogygia parabola* Hall & Whitfield.

1*f*, 1*g*, 1*h*. Pygidia showing variation in form.

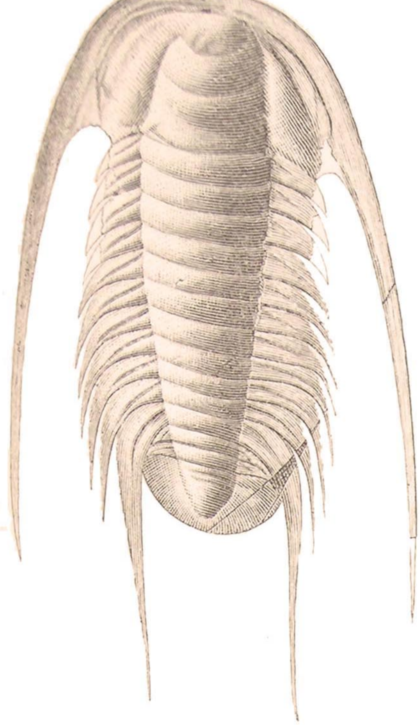
1*i*. Restoration from specimens obtained in the Oquirrh Range. Originals in collection U. S. National Museum.

Fig. 2. BATHYURISCUS HOWELLI 216

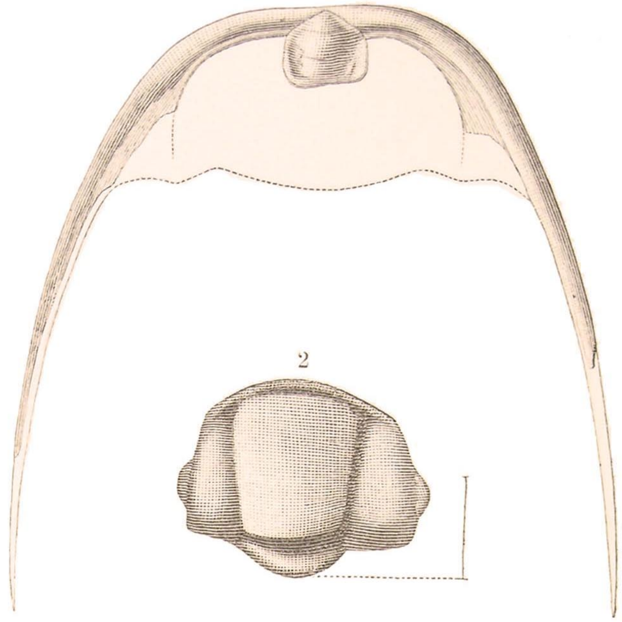
2. Type specimen, enlarged to 2 diameters. Collection U. S. National Museum.

2*a*. Central portions of head, enlarged to 2 diameters. Collection U. S. National Museum.

1



1a

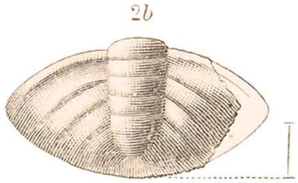


2

3a

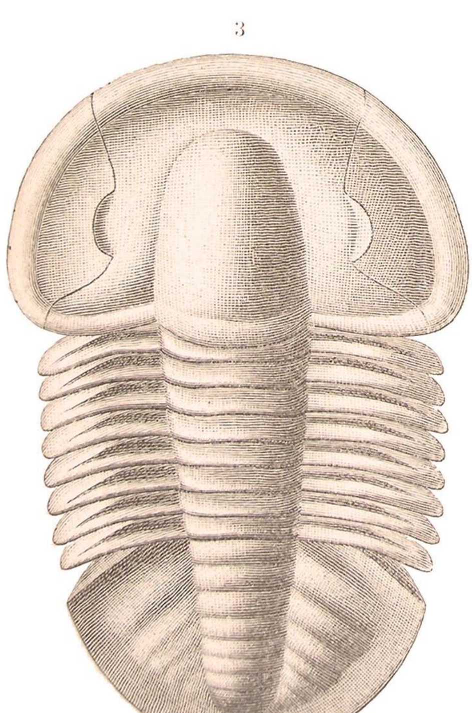
2a

2b



2c

3



4

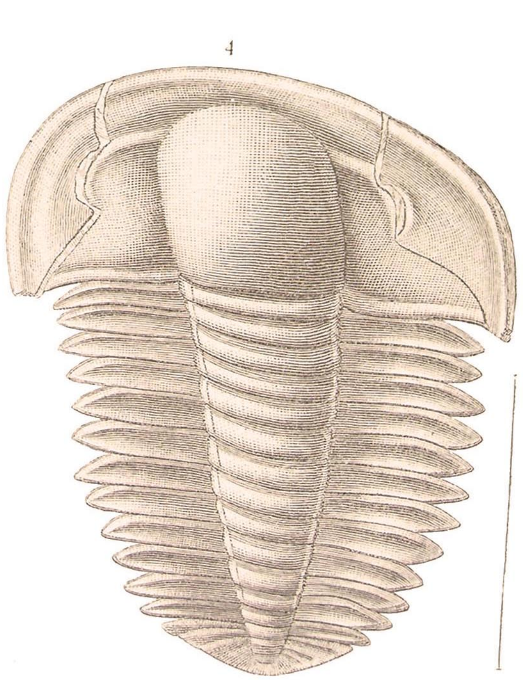


PLATE XXXI.

Page.

Fig. 1. BATHYNOTUS HOLOPYGA 191

1. View of a nearly perfect specimen; the long eye-lobes are crushed down. Natural size. Collection U. S. National Museum.

1*a*. View of the free cheeks and hypostoma in position. Collection U. S. National Museum.

Fig. 2. PROTYPUS SENECTUS 213

2. View of flattened specimen. Collection U. S. National Museum.

2*a*. Specimen laterally compressed. Collection U. S. National Museum.

2*b*, 2*c*. Pygidium associated with the heads 2 and 2*a*. Collection U. S. National Museum.

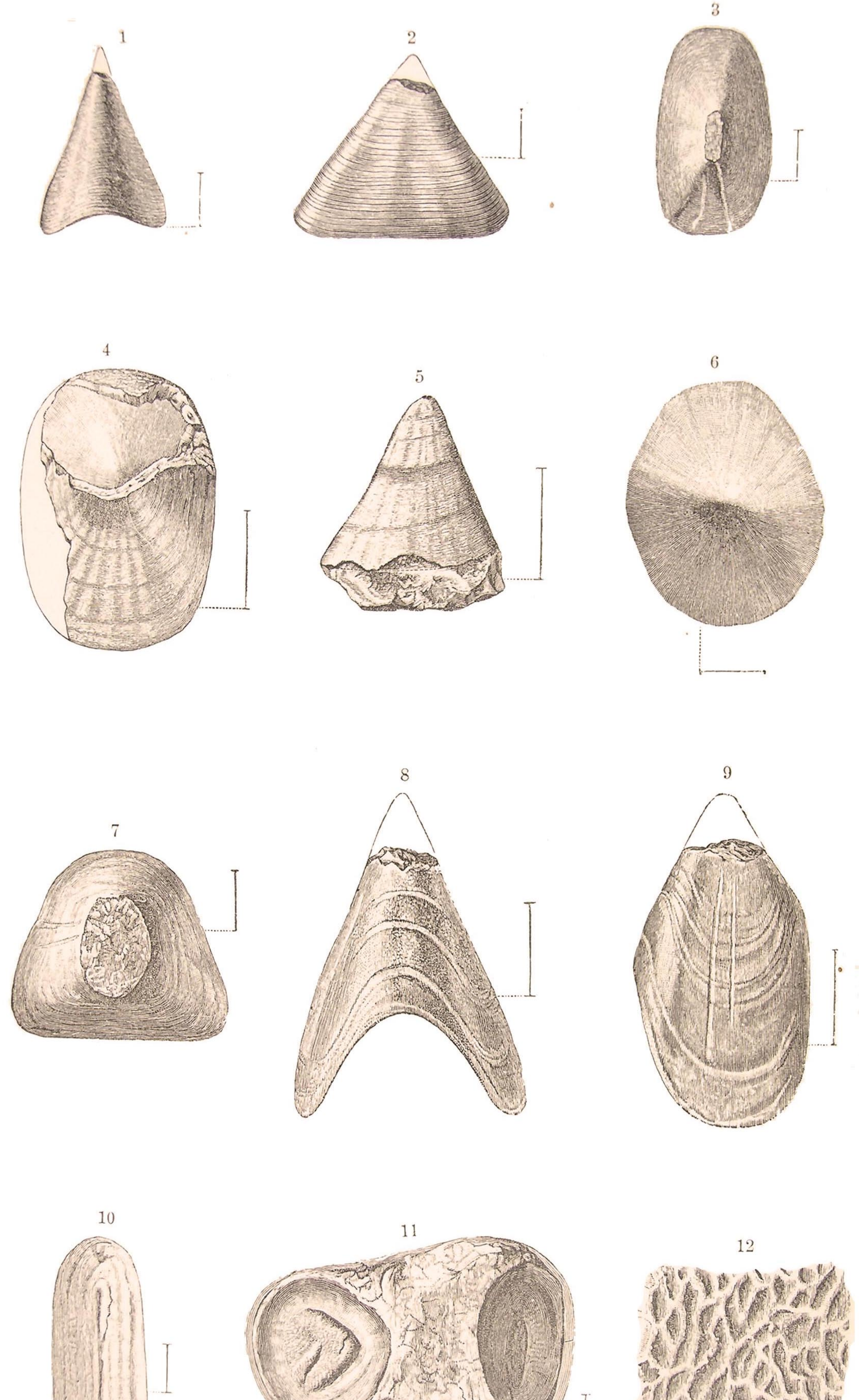
Fig. 3. ASAPHISCUS WHEELERI 220

3. A figure partially restored, as a portion of the pygidium and free cheeks is broken away in the type specimens. Collection U. S. National Museum.

3*a*. A head that has a strongly-marked glabella. Free cheeks broken away.

Fig. 4. PROTYPUS HITCHCOCKI 211

4. Figure of the type specimen. (After Whitfield.) Collection American Museum Natural History, New York City.



PTEROPODA.

PLATE XXXII.

1, 2, 3. End, side, and summit views of the most characteristic form, enlarged.

4. Associated operculum, with portions of the shell removed.

5. A more conical form than 1.

6. Cast of the interior of another operculum.

7, 8, 9. Summit, end, and side views of the conical variety, having a deeply sinuous margin.

10. Transverse septum crossing the inner chamber of the shell, as at s' in fig. 1*a*, pl. xxxiii.

11. Section of the apex broken off at the septa, in the inner chambers.

12. Enlargement of the inner surface of the chamber of habitation.

The originals of the above are in the collections of the U. S. National Museum.

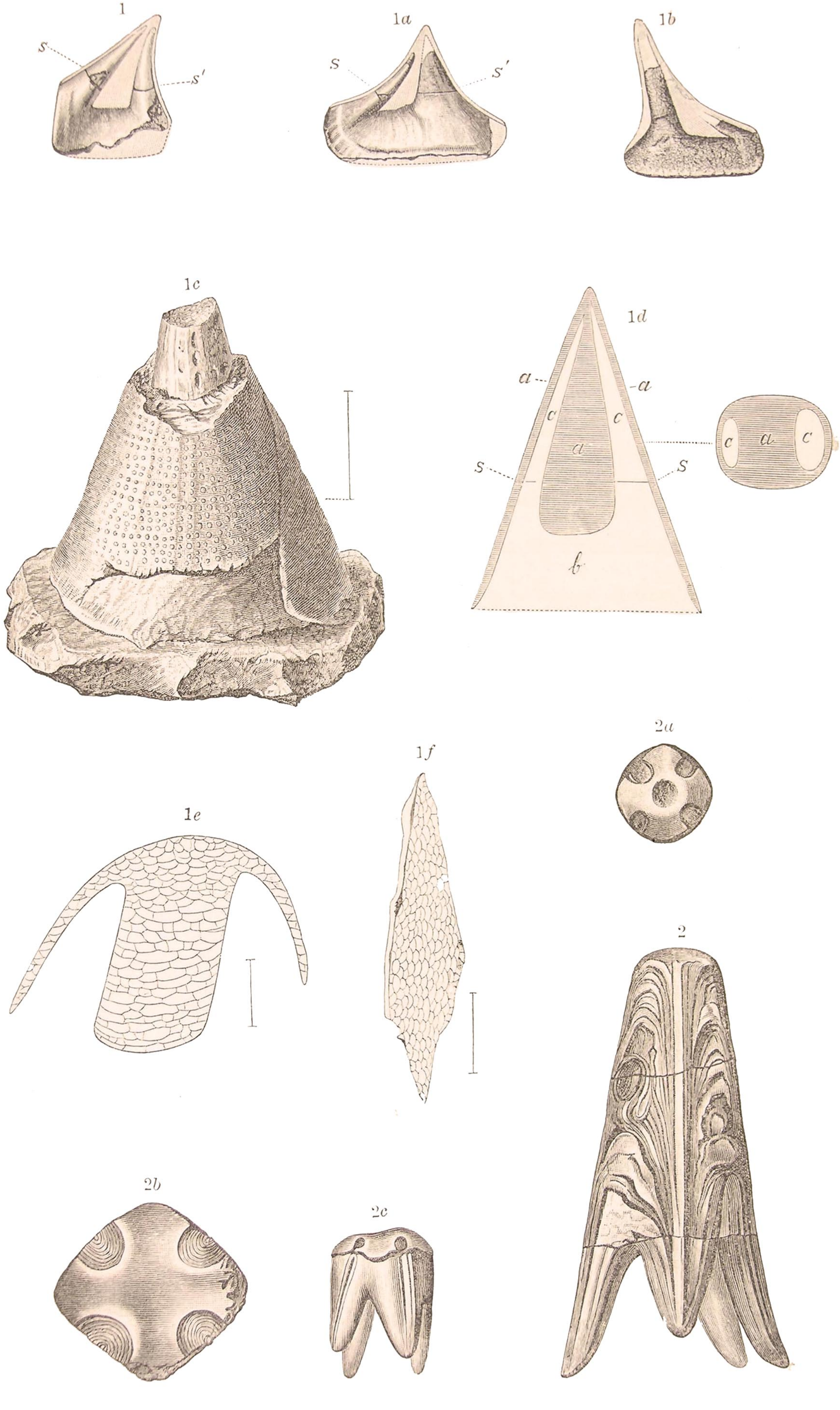

1
s
s'
1a
s
s'
1b
1c
1d
a
a
c
c
a
c
a
c
s
s
b
2a
1f
1e
2
2b
2c

PLATE XXXIII.

Page.

Fig. 1. MATTHEVIA VARIABILIS 222

1, *1a*, *1b*. Casts of the chamber of habitation and the inner chambers. The septa are seen at *s*, *s'*, and the outline of the shell is traced. Collection U. S. National Museum.

1*c*. End view of a conical specimen. The cast of an inner chamber and the relative thickness of the outer shell are shown; also, the character of the outer surface. Collection U. S. National Museum.

1*d*. Diagrammatic transverse section to show the shell (*a a*); the inner chambers (*c*, *c*); the chamber of habitation (*b*), and the septa (*s s*) between the latter and the inner chamber; (*x*), transverse section of the shell and inner chambers.

1*e*, 1*f*. Enlarged sections of the shell to show its peculiar vesiculose structure. The section (1*e*) is oblique to the axis of the shell, which gives it the irregular form. Collection U. S. National Museum.

Fig. 2. PALÆNIGMA WRANGELI 221

2, 2*a*. Side view and section of summit of a specimen, the apex having been broken away.

2*b*. Summit view of what is probably the line of a septum.

2*c*. Side view of a smaller specimen than 2.